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E. W. ALLEN, Chief

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E. W. ALLEN, W. H. BEAL, W. H. EVANS, J. I. SCHULTE

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By E. W. Allen and W. H. Beal

CONTENTS

	Page
Introduction	1
The Hatch Act	2
The Adams Act	2
Purnell projects	6
State support	8
Expansion of work	10
Cooperation	10
Standards and motives in research	11
The Arizona station	13
Essentials of good administration	14
Personnel	15
Additions to buildings and equipment	19
Insular experiment stations	21
Some results of recent station work	22
Methods in feeding experiments, by George Haines	85
Home economics research under the Purnell Act, by Sybil L. Smith	89
Publications of the stations	97
Income, expenditures, and other statistics	113

INTRODUCTION

The year 1925–26 was one of unusual growth and activity in the agricultural experiment stations. It marked a new epoch in their development, for it was the first year under the Purnell Act of 1925, which not only increased the funds for the maintenance of the stations but made it possible to enlarge their field of research, especially in agricultural economics, home economics, and rural sociology. The act added to the administrative duties and responsibilities of the department and greatly increased the activities of the Office of Experiment Stations, which represents the department in the administration of the Federal funds provided for the support of the stations.

The financial effect of the Purnell Act was to add in the first year less than a million dollars to a ten million dollar enterprise, but in the opportunity it gave to expand the station work in new lines and to develop broader relationship to the whole enterprise, the act meant much more than the relatively small increase in financial support would indicate. The aim to make the increased aid supplement in the most effective way possible the activities already under way, and to stimulate the work of the stations as a whole so as to mark a distinct forward step in their history, necessitated much attention to programs and policies, the development of plans for spending the new fund on the basis of definite individual projects, and fitting the new work into the general scheme.

A high ideal was held up for the new projects, in order that they might express the actual status of research in their respective fields and represent advance in the approach to them or in the concrete nature of the objective. There were plans, furthermore, for a greater measure of cooperation and coordination and more concerted attack on broad problems than formerly—at least for keeping better informed as to the progress of current investigation.

The organization, manning, and equipment of departments in the stations to prosecute the new lines of investigation, and the determination of programs for them, called for unusual administrative attention and brought new problems. Some difficulty was found in obtaining trained and experienced workers in the newer subjects because of the relatively limited previous opportunity for research in them and the consequent scarcity of prepared investigators. This required the exercise of judgment in selecting project leaders and frequent delay in filling positions and starting new projects. Often the new recruits were unfamiliar with station policies and

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procedure, and in some of the subjects the field of research was not very clearly organized and defined.

In the more familiar subjects relating to production these difficulties are encountered in less degree, but the enlargement of the working force and the setting up of new projects so as to supplement where most needed the research already under way, called for broad consideration of the relative needs and merits of particular lines. The subjects suggested for investigation or in which advice was requested were more numerous than could be met with the new appropriation at the outset, and this fact necessitated careful discrimination in enlarging the research program.

It is evident that the new fund was not accepted as a mere addition to existing resources, to be absorbed in the general activity of the stations, but as one for the development of agricultural investigation on the basis of carefully considered projects, each accepted on its merits and importance.

This report, prepared in compliance with the provisions of law, deals with the operation, problems, and outlook of the experiment stations under the Hatch, Adams, and Purnell Acts and of the enterprise as a whole. Operation under the Federal acts and the State appropriations is so closely knit that each influences the other and contributes to the success of the whole.

THE HATCH ACT

The fund of $15,000 annually to each State, authorized under the Hatch Act of March 2, 1887, may be regarded as a general utility fund of the experiment stations. It is employed to a considerable extent for a great variety of purposes connected with the administration of the stations, overhead expenses of a general character applying to the stations as a whole, and to supplement other sources of revenue.

The two other Federal funds, and in many cases the State funds, are more closely restricted in the purpose to which they may be applied than is the Hatch fund. The Hatch fund furnishes a means of providing for expenditures which, although essential to the stations' operation, might be questioned under the limitations applying to other funds. With restrictions on out-of-State travel and attendance on scientific meetings, limitation on the amount of salaries from State funds, etc., the Hatch fund has been an important means of meeting local difficulties of administration.

The Hatch Act has been the real basis of many of the stations in the past, and has continued to play a highly important part in their operation. Although the fund is not as extensively assigned to specific projects as the two other Federal funds, to an increasing degree it is being used on particular projects, and this course is being urged in order to make more definite showing of its use.

THE ADAMS ACT

The past year completed 20 years of investigation under the Adams Act. That act, approved March 16, 1906, came after 19 years of operation under the Hatch Act, and at a time when the stations had begun to feel the need for funds which could be devoted to the more advanced ranges of original research, free from pressure for immediate results. The intricate nature of many of the problems which were being dealt with was fully evident, as was the fact that these required research of more fundamental character if continued progress was to be made. The act, therefore, was a response to the feeling that there should be larger opportunity for quiet, undisturbed research than was possible in any considerable degree with the resources available and the demands for results.

The new supplementary legislation started with an appropriation of $5,000 to each State, increasing by $2,000 a year until it reached maturity in 1911, authorizing an appropriation of $15,000 for that year, which has since been continued annually. This provision for gradual enlargement of the appropriation was a wise one, for not all of the stations were fully prepared at that time to use to advantage an appropriation of the ultimate amount provided. The gradual increase gave them opportunity to adjust themselves and their forces to the new provision.

The standards set from the first have been an incentive to high-grade, thorough-going research. This fact has served to attract new recruits who saw larger opportunity for a research career in this field, and has proved an inspiration to others to prepare themselves by thorough training. The fund has been a very potent factor from the first in encouraging this grade of work, and it has steadily paved the way for increasing amounts of it. It has, therefore, served the double purpose of supporting definite lines of original inquiry and of stimulating more extensive growth of it throughout the stations.

The administration of the Adams Act was placed on the basis of concrete projects, to the support of which definite allotments of funds were made by the respective stations. This was the beginning of the employment of the project system on any general scale by the experiment stations. This system now has become an established procedure, with State as well as Federal funds, and makes possible a general survey of the investigations in this group under way at the present time.

ADAMS FUND PROJECTS

There were 443 research projects supported in part or wholly by the Adams fund. During the year 63 new projects were inaugurated and 58 were concluded or transferred to other funds. A few of the latter were placed on the Purnell fund, while some others were given supplementary support by that fund.

The number of projects per station ranges from 2 to 17, these extremes being quite exceptional. Many stations have from 7 to 12 projects, and the average for all is 9 and a fraction. This gives an average support from this source of about $1,625 per project. There is wide variation in the financial assignment, however, dependent in part upon the nature of the individual project, the number of projects a station is supporting on the fund, and the extent of other available resources. There is no available estimate of the State contributions toward the support of these projects, but in very many cases the Federal fund devoted to them is doubled.

Some idea of the range and character of the Adams fund projects may be gained from their classification. By far the largest group (94) deals with plant diseases and related troubles, soils and fertilizers coming next in number with 60, and breeding and genetic studies with 54. There are 44 projects dealing with economic insects, 43 with animal diseases and pests (including poisonous plants of the western ranges), 41 on various botanical, breeding, agronomic, and other aspects of field crops, and 38 in horticulture and forestry. Fundamental studies of nutrition and animal production are represented by 36 projects; dairying has 11; agricultural engineering, 4; and the remaining 18 relate to chemical studies of various kinds, the technology of cane sugar making, and miscellaneous subjects.

Within these various groups the projects range quite widely. The subject of soils and fertilizers includes investigations on the nutritive requirements of plant growth and factors affecting them, the availability and utilization of plant nutrients in soils under different methods of treatment, the toxicity of soils due to various causes, the nature and formation of humus, the physical-chemical aspects of soil acidity, the influence of rotations on maintenance of soil fertility, problems of alkali soils and their treatment, the importance and action of sulphur, manganese, and magnesium compounds in the soil, fundamental soil-moisture constants, and a variety of studies on the bacterial activity of soils, factors influencing it, and relationship to fertility.

The water requirements of crops as related to plant characters and environmental factors, the influence of soil types and of fertilizers on the composition of crops, relation of light to plant response, the duty of water on crops as affected by various conditions, and factors influencing the growth and development of special plant parts, such as cotton buds and bolls, constitute another group. Conditions which affect the milling strength and baking qualities of wheat flour is the subject of several projects, while others are devoted to biochemical changes due to various causes, such as frosting of wheat, and their effects on bread-making quality and market value. There are physiological studies relating to changes in the ripening of crops and in their storage and transportation, the latter notably with potatoes and sweet potatoes.

Of interest to range agriculture are numerous studies on the toxic properties of poisonous plants and the stage of growth at which they are particularly dangerous; and studies of the injury to grazing tracts by rodents and the means of their control.

The work in genetics includes both plants and animals. Under the former come studies of general principles, the laws and modes of inheritance, the value of mutations, linkage relations and variability, and the application of breeding principles in the systematic improvement of a great variety of field crops and fruits. With animals, the breeding work includes such subjects as inbreeding, inheritance of milk production and associated characters in cattle, analysis of hereditary factors determining milk and meat production, principles involved in fixing certain desirable characters in sheep, inheritance of fleece characters in purebred and crossbred sheep, fecundity of swine and conditions affecting

it, cause and control of sterility in mares, and inheritance and physiology of various qualities in poultry.

The subject of plant diseases and similar troubles is a very active one, as indicated by the classification above. A wide range of diseases affecting a large variety of plants are under study as to their pathological, biological, and physiological relationships, as well as means of control. Mosaic diseases of crops, the degeneration troubles in potatoes, the means of transmission of disease in obscure instances, and the basis or nature of resistance and susceptibility occupy a prominent place. Notable among the latter are studies of the relation of nutritional deficiencies to prevalence of corn rots, the influence of temperature and moisture conditions on plant infection, and the physiological aspects of parasitology as a key to the occurrence of these troubles. The biologic or physiologic forms and races of disease organisms and conditions producing them are the subject of another important series of investigations.

The study of economic insects, the factors influencing outbreaks, parasitic enemies, and other means of control, have always constituted a prominent feature of the Adams fund program. The present list of such studies is a long one, as the classification shows. In addition to the detailed investigation of individual insects and groups, a dozen or more projects relate to the chemical and physical properties of insecticides and fungicides, the manner in which they operate, and their effect on foliage; while others deal with insect attractants and repellents in relation to their chemical nature, and arsenical residues on fruits—the means of removal and effect on storage.

Horticulture comes in for a goodly number of thoroughgoing investigations, especially as related to the physiological manifestations in the group of plants it represents, such as the nutrition of apple trees, the influence of fertilizer applications on the physiological functions of the tree, fertility and sterility of varieties, fruit-bud formation, pruning in relation to growth and as a factor in blooming and the setting of fruit, value of bud selection in the apple, factors determining hardiness, and the nature, cause, and prevention of winter injury.

The subject of vitamins, which has been so richly contributed to by the work of the American stations, continues to receive much attention, including not only studies of their relation to proper nutrition but factors which affect them, such as conditions of growth and curing of crops, effect of commercial processes in condensing milk, relation to breed of cows, and capacity of storage in the animal body. Other nutrition studies pertain to the nature and value of proteins from various sources, the requirements of protein and energy for different purposes, the importance of ash ingredients, mineral metabolism and mineral requirements, basal metabolism studies, protein storage in protoplasmic tissue, and a long list of other fundamental investigations in nutrition, many of which have applications to man.

With poultry there are projects relating to feeding and management as affecting the vigor of germ in hen's eggs, effects of deficiencies of feed of hens on the vitality of chicks, conditions of incubation, and the nature and cause of watery whites in eggs.

There are numerous studies on the physiology of milk secretion, the chemistry of milk and its constituents, dairy and creamery sanitation, factors causing sandiness and swell in ice cream, and tolerance and nutritive value for children of milk of varying composition.

Most prominent among the studies of animal diseases are abortion, hog cholera, tuberculosis, and white diarrhea of chicks, but in addition a considerable list of other diseases affecting various kinds of livestock are under investigation.

The above survey is in no sense exhaustive but is designed merely to give an idea of the range of the research and the fundamental subjects with which it is dealing. Its significance is not confined to agriculture itself, but in large measure the studies are of very vital importance for the welfare of the human race in its proper feeding and the maintenance of health and in meeting the prospective demands of increasing population.

STABILITY OF ADAMS FUND RESEARCH

Of the 443 projects active during the past year, 126 have been in operation for from 5 to 10 years and 119 for 10 years or more. Of this latter group three-fourths have been under way for from 10 to 15 years and the remainder from 16 to 20 years. No less than 22 projects have been continued since the beginning of the fund, many, however, having been restated to conform with progress and changes in the course of investigation.

This shows the stability of research under this fund, a highly important fact when it is considered that the research relates very largely to problems of an intricate character whose solution often requires many years of study. Such subjects as the cumulative effect of various treatments on soils, the nutritive requirements of apple trees at different stages of their growth, the interrelation of stock and scion, or the nature and transmission of an obscure disease or physiological trouble, naturally require protracted research which should not be interrupted until definite conclusions have been reached. Other projects develop and expand as the study of them progresses. One step leads logically to another, and this serves to give the work continuity over long periods.

It is in accordance with the nature of research that its course should change with advancing stages and that the procedure should be adapted to the needs which such progress develops. This is not to be confused with vacillation and shifting of purpose. Although the point of view and the means employed may shift, purposeful inquiry adheres to the objective as long as there is adequate encouragement to do so. There is occasional tendency, however, to prolong a project by digressing into unrelated side lines, without completing or bringing to a definite stage the research upon the subject originally attacked. There is some evidence also of disposition to allow projects to become stereotyped after they have been laid out, and to continue to accumulate data without certainty that the process represents advance or that the method is proving adequate. Such a tendency overemphasizes the feature of continuity, and fails to stress constructive study with concentration on a definite objective.

There is considerable difference among stations in the latitude allowed in interpretation of the scope of research projects, and much variation in the extent to which such projects are kept revised. Sometimes it becomes necessary for the Office of Experiment Stations to call for a restatement, or occasionally for a realignment of the investigation. This is not designed to control the course of the investigation or to insist on projects being continued when the local authorities feel it is desirable to discontinue them, but rather to discourage a disposition to vacillate, to lose interest in a project because something else has come up which proves attractive. An investigator who lacks the persistence and seriousness of purpose to carry through a project, as long as it holds promise, is hardly suited to advanced types of original scientific research.

The primary object in the administration of this fund has been to conserve it for lines which mark progress and hold promise, and to keep the project statements reasonably up to date, as an expression of the status of the investigation as well as of its nature and purpose. This effort has met with cordial response, which has resulted in the high type of work maintained under the act.

PURE VERSUS APPLIED SCIENCE

There is frequent reference to the distinction between pure and applied science, with emphasis on the importance of research which develops science for itself. The essential character of this type of research as the basis for progress in applied science and the growth of industry is thought to need popular exposition. Since its practical value is less evident to the public mind, it is likely to be regarded as more remote and to receive less appreciation and support.

Research in agriculture has been commonly thought of as being in the field of applied science, and hence of a different order from that which has no applications in sight. The latter, because of the specialized interest in it, is sometimes regarded as more abstruse and intensive. In the earlier stages the maintenance of such distinctions was often regarded as essential, and caution was exercised to restrain workers from straying into the field of pure science.

Experience under the Adams Act, with the attendant development of more original and abstract research, has changed this attitude. It has been especially illuminating in showing the relation of abstract research to the solution of questions presented in agriculture. These questions can not be answered in a satisfying or adequate way by reliance on ready-made science; investigators attacking them must in large measure make or develop new science, extend its boundaries, fill in the gaps, and unify the whole.

While the ultimate purpose of such research is the service of agriculture through science, it has come to have much in common with pure science research. Its underlying motive is to get at the truth, and this frees it from narrow restraint. It is not confined to applying what science has produced, but is a definite attempt to enlarge the field of scientific knowledge by further discovery and unification. Such

research is not limited in its thoroughness or the depth of its penetration by any narrow discrimination between what relates directly to an applied question and that which enables the theory and the science of the subject to be better known.

Many a station investigator is now carrying on research which, for the time being, is pure and fundamental and unrestricted by any idea of immediate application. The fact that later on use may be made of its results in explaining phenomena in practice does not alter its abstract or fundamental character. Such studies as those relating to the chemical nature of proteins, the unraveling of the mystery about vitamins and their relation to normal growth and health, the factors which go to make up susceptibility to disease or account for the prevalence of infection and outbreaks—these and hundreds of others of similar character are not essentially different from pure science research in fields of less general interest. They demonstrate that there is no antagonism, no impropriety, no sacrificing of public interest by the taking up of such lines of study.

This type of inquiry by the stations, therefore, no longer needs defense. Relating as it does to the whole range of life and its environment, it furnishes an almost unparalleled illustration of the value of abstract research, and it fills a large place in the advancement of scientific knowledge.

There is a difference in projects as there is in workers with regard to the nature of the investigation and the source of the science. Some workers and some projects will rely mainly upon the existing fundamental facts, assembling these from various sources and interpreting them in relation to the question in hand, while other investigations, if thorough, will soon lead into the field of acquiring new facts of science. There is need for the two general classes of investigation, and there will continue to be need of the latter in increasing degree.

The Adams Act was a recognition of these facts. It was to encourage fundamental research, with application as its ultimate motive but not its limiting factor. There can be no question of the inestimable advantage of this act during the past 20 years, not alone in the results it has brought but in the standards and the spirit it has inculcated. Its constructive value has been far in excess of its proportion to the total maintenance funds. With enlarged support for station work, there is further opportunity to preserve the ideal which has become a tradition, and studiously to reserve the Adams fund for the more advanced type of scientific research at the experiment stations.

PURNELL PROJECTS

A total of 680 projects have been organized under the Purnell Act of 1925. The number per station ranges from 5 to 24, the average being a little over 14. Three States have only 6 Purnell projects and 4 others have 8 or 9, while 5 have 20 or more. At 40 stations 10 or more projects are carried on this fund, and 28 exceed the average mentioned.

The projects fall in the following groups: Soils and fertilizers 27, genetics and plant improvement 22, field crops 30, pastures and ranges 12, horticulture and forestry 39, plant diseases 32, entomology 43, animal production 83, dairying 30, veterinary science 17, rural engineering 16, home economics 91, agricultural economics 215, and rural sociology 23.

Of the total number, 351 projects deal with production subjects, whereas 329 are in the newer fields of home economics, agricultural economics, and rural sociology. Thirty-five per cent of the whole number relate to agricultural economics and sociology, and 13½ per cent are in home economics. This makes a good showing for the new subjects. Although the number is somewhat less than in the field of production, considerably more than half the Purnell fund is apportioned to these newer lines of inquiry.

All but 2 States have projects at present in agricultural economics, home economics, or rural sociology. In 12 States these subjects constitute fully three-fourths or more of the total Purnell projects. In 24 States they comprise from one-half to 100 per cent of the projects. At 6 stations the entire Purnell fund is devoted to these groups of subjects, with none allotted to production subjects.

Agricultural economics supplies the largest number of projects under any subject. Such projects are in progress in all except four of the States. One State has 18 projects in economics, or two-thirds of its entire list, and another has 11 projects, or one-half its total. The subject has been energetically entered upon, and the projects cover a very wide range of subjects relating to marketing channels and machinery of distribution of farm products, terminal grain mar-

kets, warehousing and elevator management and cooperation in buying and selling—success and failure and principles of effective management. Farm management and farm organization, costs of production, and types of farming areas represent a considerable group; and there are also investigations of the status and condition of cattle and sheep raising on western ranges, dairying in the Northwest and stock raising in the Coastal Plain region of the South, the apple industry of New England and the peach industry in other sections, with reference to possibility of expansion, and similar inquiries as to the economic adaptation of various agricultural industries to different sections. Land economics, values, prices, cycles, and successful utilization represent another group of projects, and closely related are the subjects of tenancy, taxation, credit facilities, farm-labor turnover, and the like.

The economic field covered is a wide one, much of the work being in cooperation with the Bureau of Agricultural Economics of this department. It is safe to say that nothing of the kind in this subject has ever before been undertaken on so extensive a scale.

Home economics ranks next to agricultural economics in the number of projects under this new fund. All but 10 of the States have inaugurated new projects in that field. Some of the others have work under way which relates to that subject but is conducted with other funds or under other auspices.

The projects in home economics fall under the general heads of food and nutrition, including studies on the vitamins and the importance of other minute food accessories, household management, and clothing and textiles. The projects in nutrition cover such subjects as baking qualities of flour of different origin and from different sections, fruit juices and the jellying of fruits, spoilage of canned vegetables, the utilization of calcium and phosphorus from fresh, dried, and evaporated milk, causes for variation in the cooking quality of potatoes, diet and nutritional diseases of children, the food habits of farm families in different sections and their expenditures for food, and food consumption in relation to standards of requirement and income. The household management projects include such subjects as fuels for cooking purposes in rural homes, application of electricity in the home, routine and seasonal work of the housekeeper, household budgeting and accounting, and labor-saving devices. An interesting study under the head of textiles relates to factors affecting the penetration of ultra-violet rays of the sun through animal and vegetable fibers.

The subject of rural sociology is less definitely developed from the standpoint of research than some of those in which there are an accumulated experience and a clearer method of approach. However, much effort has been given to developing effective projects in this field which would disclose not only the conditions and attitudes but avenues of beneficial improvement.

Thirteen States have provided for work in rural sociology and have 23 projects under way. These relate to the organization of typical rural communities, types of rural social institutions, and the effective location of rural centers for such institutions as churches, schools, libraries, clubs, etc. Others deal with the attitude of rural people toward organizations, especially for improving social and other conditions in the country, introducing better facilities, and securing proper recognition of the relation of town and country interests; while several are devoted to rural leadership, and to young people's organizations as factors in rural life. The farm population is being studied with reference to movement to towns and cities, the relation of this to community advantages and to individual ability, and the attitude of farm families toward farm life, with the reasons. Although the beginning is a small one, the subject is one which is expected to grow as its importance and its fundamental bearing on farm living are developed.

The studies, under the Purnell Act in the general field of production, cover a wide scope, as is indicated by the classification mentioned above. For the most part these are new projects and to that extent supplement the programs of investigation previously under way. Usually the subjects are carefully selected because of the need for information on them. As a group, they represent a high type of investigation directed mainly at practical questions but approached by thorough methods of investigation. The standards set are not outranked by those of any class of investigations at the stations except the Adams projects, which are more uniformly of fundamental character.

There has been some tendency to overload the Purnell fund, with consequent danger of inadequate financing of individual projects. This has grown out of the large demand for taking up investigations in new lines or on new

subjects. It has been quite carefully guarded against by the stations, and the office has paid special attention to the budgets as a means of insuring adequate support of new proposals. Although the fund is increasing it may easily fall into the previous position of other funds, i. e., of being allotted to more new projects than it can support as they develop and present new requirements. To avoid this may require caution, and will at least warrant attention to the allotment of support from this fund and from supplementary sources. Many of the new projects are receiving considerable aid from other funds of the stations.

PROJECT OUTLINES

In the analysis and criticism of the new projects submitted, the attempt has been in each case to develop a clear and reasonably limited objective, to bring out the new ideas which lay back of the investigation, either as to the nature of the problem or the means of approach, and to fit the new work into the existing background. The aim has been to place the program of investigation on a high plane, having regard at all times to the immediate or the ultimate practical bearings of the results. The effort has been to avoid mere duplication or useless repetition, and to discourage the more conventional type of trials and experiments which do not take account of the existing status of investigation or disclose a new point of view in the plan and attack. The purpose has been to obtain a systematic, well-rounded program of research, made up of clear-cut concrete proposals for sound investigation in accordance with modern conception and present knowledge, of such number and scope as can be studied in a thorough and conclusive way with the means available.

Much emphasis has been placed upon the importance of a carefully considered project outline[1] in the belief that careful planning in advance will tend to raise the standard of investigation by defining clearly the question to be studied, indicating the major sources of information and their specific bearing upon the subject of study, and deciding upon a procedure adequate to the undertaking. Such careful planning, it is believed, will also serve as a helpful administrative aid in carrying out a definite and effective research policy and will strengthen the investigator's own approach to the subject, as well as make possible intelligent judgment upon the merits of the proposed work and its progress.

STATE SUPPORT

The question is sometimes asked whether the States are leaning on the Federal Government in the support of experiment stations, or, if not, whether new legislation increasing the Federal support would not encourage them to do so. This is partly suggested by the fact that no State offset is required for either of the three Federal appropriations. Such an offset was considered in connection with the enactment of the Purnell Act but discarded because the benefits of research are not limited by State boundaries but in very many cases are national. Furthermore, they supplement the investigations of the central Government, and they may be as important in a small State as in a large one, while there is wide disparity in the burden different States would feel in meeting the uniform Federal appropriation.

As a matter of fact, in the past the appropriations from the General Government have proved a stimulus to the States, which have not only supplied the buildings, land, and similar facilities, but made increasing appropriations for station maintenance. The Association of Land-Grant Colleges and Universities has indorsed the view that the Purnell Act was not designed to relieve the States of their obligations to the stations, and that assent to the act would imply responsibilities for added capital outlay to meet enlarged requirements. There is no question that already this enlargement of the stations has presented necessities which it has been difficult to meet in the absence of legislative sessions. However, a number of States already have provided new buildings or additional land, and where specific appropriations were lacking the colleges have met these needs from their regular funds to a considerable extent.

The expenditure from the Purnell fund for buildings and land has been held within reasonable bounds and has not been for general purposes of the stations but restricted to the specific needs of projects under that fund. The total charges of all the stations for such items in 1926 amounted to less than $18,000, whereas the 10 per cent allowed by the Purnell Act would aggregate $96,000. Only a single station used the full amount allowable, which was applied to the purchase of

[1] For fuller discussion of this subject see the following: ENGLUND, E. THE PROJECT OUTLINE IN AGRICULTURAL ECONOMICS. Expt. Sta. Rec. 55: 301–305. 1926.

additional land. This shows acceptance of the general principle of looking to the States for major capital expenditures.

There have been only isolated cases of proposals to reduce State appropriations or college allotments to the station by reason of the coming of the Purnell fund. Such tendencies have been resisted by the department, reinforced by the Association of Land-Grant Colleges and Universities, which has felt a keen responsibility for keeping faith with the General Government in this matter. Indications are that the policy now has become a recognized principle of action.

For the fiscal year ended June 30, 1926, the stations in the 48 States had total resources amounting to $11,956,760.43, an increase of $1,613,064.56 as compared with the preceding year. This increase was due largely to the first annual appropriation under the Purnell Act; but if, for the sake of comparison, the Purnell total of $960,000 is not included, there remains an increase of $653,064.56 as compared with an increase of $309,621.31 for the year ended June 30, 1925, over the year ended June 30, 1924. Of the total amount the stations had for their use the past year, $9,556,760.43 was from State sources. Direct State appropriations aggregated $6,526,818.02. Balances brought forward from the preceding year amounted to $663,834.29. The total from sales was $1,470,550.11. The remainder, $895,558.01, was derived from fees and miscellaneous sources. Totals by States are shown in Table 1.

TABLE 1.—*Income of the agricultural experiment stations from within the States for the year ended June 30, 1926*

States	State appropriations	Balances	Fees	Sales	Miscellaneous	Total
Alabama	$34,500.00	$14,586.98		$7,654.82	$10,000.00	$66,741.80
Arizona	99,242.79	775.43		6,147.89		106,166.11
Arkansas	57,755.76			14,600.00		72,355.76
California	466,444.76	30,534.63	$12,807.78	101,422.23	20,426.96	631,636.36
Colorado	104,343.37	27,875.27		36,721.07		168,939.71
Connecticut State	167,697.10	157.38	19,000.00		10,500.02	197,354.50
Connecticut Storrs	32,000.00	3,901.13			19,033.31	54,934.44
Delaware	18,500.00	2,308.50		18,771.13		39,579.63
Florida	273,381.50	7,368.21		9,704.59		290,454.30
Georgia	8,800.00	347.52		8,017.38		17,164.90
Idaho	46,288.69	1,361.49		3,282.89		50,933.07
Illinois	380,254.94	17,962.39		57,006.17		455,223.50
Indiana	209,137.16	140,830.92	122,443.51	83,597.73	54,871.03	610,880.35
Iowa	265,000.00	9,630.14		35,463.24		310,093.38
Kansas	102,400.00	28,809.42	39,134.06	19,119.17		189,462.65
Kentucky	111,932.77	27,407.34	97,729.30	61,906.60		298,976.01
Louisiana	50,093.10	569.91	30,336.90	7,067.20	14,120.52	102,187.63
Maine	38,000.00		10,016.24	19,650.68	995.40	68,662.32
Maryland	80,221.42	709.28		16,825.86	16,338.20	114,094.76
Massachusetts	128,904.32		42,731.30	18,089.76	2.20	189,727.58
Michigan	288,000.00			36,052.68	946.74	324,999.42
Minnesota	221,504.39		99,311.46	83,460.64	2,249.97	406,526.46
Mississippi	103,479.57	17,043.46		12,921.78		133,444.81
Missouri	37,059.62	20,146.38	34,545.18	43,528.90		135,280.08
Montana	101,883.09		4,013.92	23,249.12	1,069.80	130,215.93
Nebraska	112,416.39			66,015.89		178,432.28
Nevada	3,043.89	937.04		4,007.61		7,988.54
New Hampshire	4,500.00	3,996.58		1,644.02	18,876.71	29,017.31
New Jersey	106,483.89		61,892.02	37,223.66	132.53	205,732.10
New Mexico	7,500.00	20,291.72		10,000.00		37,791.72
New York Cornell	240,896.01			28,358.22		269,254.23
New York State	285,025.00	8,678.07		10,860.42	3.50	304,566.99
North Carolina	60,000.00			19,821.62	385.58	80,207.20
North Dakota	265,400.00	57,023.82		70,176.45	11,025.00	403,625.27
Ohio	710,200.00	120,591.25		57,221.47	4,024.72	892,037.44
Oklahoma	30,000.00	2,857.17		16,217.36		49,074.53
Oregon	117,000.00	37,771.38		45,139.73	13,399.85	213,310.96
Pennsylvania	73,934.97			3,136.89	13,095.43	90,167.29
Rhode Island	1,393.02			5,175.20		6,568.22
South Carolina	72,255.01	1,805.21		42,363.27		116,423.49
South Dakota	57,920.00	11,670.94		17,207.22		86,798.16
Tennessee	37,351.03			18,197.73		55,548.76
Texas	270,048.82	15,650.18		101,457.76	66,907.24	454,064.00
Utah	60,223.62			22,319.24		82,542.86
Vermont			16,072.50	1,208.32		17,280.82
Virginia	72,588.33	10,983.08		8,557.30	1,961.51	94,090.25
Washington	111,222.06			49,390.75		160,612.81
West Virginia	96,500.00	3,593.03		41,442.43		141,535.46
Wisconsin	249,637.45			59,657.96	25,157.62	334,453.03
Wyoming	54,454.15	15,659.04		9,488.06		79,601.25
Total	6,526,818.02	663,834.29	590,034.17	1,470,550.11	305,523.84	9,556,760.43
Federal funds						2,400,000.00
Total						11,956,760.43

As in the preceding year, all the stations received State aid in 1926, but in several instances the amount of State support was small. The State appropriations of four stations remained without change, while those of 27 stations showed an increase and those of 19 a decrease. Three stations, Illinois, California, and Ohio, mentioned in the order of increasing amounts received, reported State appropriations or allotments amounting to more than $300,000. Nine stations similarly enumerated received between $209,000 and $288,000, namely, Indiana, Minnesota, New York Cornell, Wisconsin, Iowa, North Dakota, Florida, New York State, and Michigan. The State appropriations of the following 11 stations ranged between $100,000 and $168,000, viz, Montana, Kansas, Mississippi, Colorado, New Jersey, Washington, Kentucky, Nebraska, Oregon, Masaschusetts, and Connecticut State. Twelve stations receiving between $50,000 and $100,000 were Louisiana, Wyoming, Arkansas, South Dakota, North Carolina, Utah, South Carolina, Virginia, Pennsylvania, Maryland, West Virginia, and Arizona. Seven stations—Oklahoma, Connecticut Storrs, Alabama, Missouri, Tennessee, Maine, and Idaho—received from $30,000 to $46,300. The Delaware station received $18,500, and the Rhode Island, Nevada, New Hampshire, New Mexico, and Georgia stations received from $1,000 to $10,000 each. The Vermont station had no State appropriation as such, but, under a State law, devoted to experimental work the surplus remaining from the State appropriation for inspection of commercial fertilizers, commercial feeding stuffs, and agricultural seed. This surplus amounts to about $5,000 annually.

For more detailed statements of income and expenditures see pp. 113–122.

EXPANSION OF WORK

The effect of the additional funds was reflected in an increase of about 14 per cent in number of research projects. The total number of projects reported by the stations as active during the year was 6,710, as compared with 5,688 in the previous year. Deducting 58 purely administrative and regulatory projects, the number devoted to research and experiment was 6,652. Adding the 155 projects of the stations in Alaska, Hawaii, Porto Rico, Guam, and the Virgin Islands gives a total of 6,865 research and experimental projects as compared with 5,634 such projects the previous year, an increase of 1,231 projects.

The group distribution of the projects remained practically the same as in the previous year. Field crops led with 1,642 projects, followed in order by horticulture, 918; animal husbandry, 554; plant pathology, 486; agricultural economics and rural sociology, 426; entomology, 407; dairy animals and dairying, 330; soils, 321; agricultural engineering, 221; veterinary medicine, 216; fertilizers, 193; genetics, 171; home economics. 156.

COOPERATION

With the increase of projects and the broadening of the scope of the research programs, there has been a notable development of cooperative relationships and undertakings. The operation of the Purnell Act has stimulated new interest and activity in cooperative research. The selection of a limited number of national problems for cooperative study under this act and the work of the joint committees of the department and the stations, set up to aid in formulating cooperative projects and encouraging participation in them, has been very influential in this respect. The development of cooperation has been especially marked in the lines of economics, home economics, and meat production.

The extent of the participation of the stations in national cooperative projects under the Purnell Act is shown in Table 2:

TABLE 2.—*Number of cooperative Purnell projects and of States taking part in them*

Subjects	States	Projects	Subjects	States	Projects
Marketing livestock and livestock products	15	20	Miscellaneous marketing projects	12	19
Marketing fruits and vegetables	20	23	Vitamin content of foods	18	25
Apple industry in the Cumberland Valley	4	4	Rural home management	21	26
Marketing grain	7	14	Rural social organizations and agencies	14	22
Marketing dairy products	12	20	Factors influencing the quality and palatability of meat	16	17
Marketing cooperatively	8	11	Corn breeding	4	4
Marketing cotton—consumer area requirements	3	3	Total	155	209
Surpluses of farm products	1	1			

The stations are cooperating with the department in over 500 formal projects and in a large number of less formal ways. Groups of stations are attacking important regional problems cooperatively. Within the stations there is evidence of a growing disposition to disregard departmental boundaries in concerted study of important problems, which results in increased efficiency and speed in settling such problems.

STANDARDS AND MOTIVES IN RESEARCH

The work of the experiment stations in the past 20 years shows a rapid development of high standards of excellence and of the motives which lie back of them. It is one of the products of more exacting research and more diligent seeking, an enlargement of the aim to get not merely facts but understanding. It is a very noteworthy evidence of progress in agricultural research.

These standards and motives still vary very widely among individuals and, to some extent, between divisions or branches of the work. In general, discrimination is more marked in some of the older branches of research than in some of the newer ones, but within each group there is considerable variation in grade. Probably it may be generalized that the more scientific the character of a line of investigation, the more discriminating and exacting is the research in its standards and methods. In those lines which have continued to deal more superficially with practical questions, and especially with elementary conceptions of them, there has been less concern for the scientific character of the work, the means of advancing it from point to point, and the effectiveness of methods.

The standards for such work may be represented by group records, meager replication, lot feeding and weighing, even self-feeding, without data as to what individuals are doing, the range of variation, or statistical analysis of results. It may go on for years without material change, although varied as to conditions and details. In other lines the research may be constantly more intensive and exacting, seeking new avenues of approach, not satisfied unless progress is being made in knowledge as well as in tentative results. The situation therefore reflects the status of investigation of a given type, and the ideals and scientific motive which training and experience have stamped on the rank and file of workers engaged in it.

This difference in standards and essentials has no necessary relation to the desire to aid in solving problems of importance in agricultural practice. It does not mean that one group is practical and the other academic. It merely signifies a difference in conception of what is important. The desire to be helpful may be quite as strong in the worker who is exacting of himself and his work, as in one who sees the practical high spots and seeks the shortest route to reach them. The motive of one is quick action and popular results, even though these are not complete or permanent. The other finds satisfaction in doing things in a way that will endure and will advance the reason as well as the mechanics of doing. In the latter case there is what amounts to a "passion for excellence," a desire coupled with a capacity, an aptitude as well as a high motive.

Such differences in standards find concrete expression in the types of project outlines set up for new pieces of work, as well as in the means which are being followed in current investigation. In both cases they indicate how far the worker intends to carry his investigation and the kind of evidence he will demand. The motive to be of immediate service often has led to a type of testing and experimenting which is but a short step beyond current advice or a service enterprise, and this is revived in increased volume in some of the newer branches.

The lack of clear differentiation of research from other forms of service is indicated by the subjects proposed to be undertaken. These include making a survey of the agriculture of a State, preparing an agricultural map, collecting statistics and making estimates on various features of agriculture, and the formulation of outlooks expressing the general situation and prospects. These things are interesting and may prove useful, but as statistics they lie more properly in the field of State departments of agriculture, which the experiment stations should aim to stimulate rather than usurp or duplicate. Other proposals of a service nature are for computing price indexes, recording the prices at which farm lands change hands, determining the annual income from farming in a State, and supervising the improvement of a half-section farm in a new region. Again, subjects are advocated which are so broad and many-sided that the comprehensive title leads to little more than a cataloguing and summarizing of farm practice.

Of a somewhat different type, but dependent on the survey and questionnaire which have come into such prominence, are a group of projects which aim to get a "picture" of a situation—a type of farming, a branch of the industry, the financial status—and to gather material for the background. The conception and standard of requirements of such surveys and questionnaire inquiries are not always of a very exacting nature, although the objective is one of much importance. The "picture" and the "background" which they are expected to give may be very inadequate and indistinct. It may be out of proportion and out of focus. It may mislead the investigator as well as the public. This possibility is due to the fact that the work is too cursory and hasty and not adequately checked. Commonly it is not subjected to the rigid test that is applied to facts and observations obtained by the experimental method.

The attempt to get a true picture or an accurate idea of the background is by no means a simple matter, either in theory or practice. It may be premature in some cases because of lack of basic data, or in others a vain effort because of the means employed. More likely the result may be a rough sketch.

The figure of speech commonly used in this connection is reversed, for in art the main features are delineated and the background put in afterward. What in the type of work mentioned is designated the background in some conspicuous cases is made up of fragmentary information from various sources, some of it recognized as not very accurate or reliable and other parts deficient in amount and range. Upon this or from this a picture is drawn which is assumed to be a likeness but is not easily compared with the original for verification. Large regional problems are worked upon in this way, often through cooperation. For many of the cooperators the danger is that the investigation will evaporate into vast general and hastily conducted surveys which will be pieced together and summarized as expressing a broad general fact, an average of conditions, or a combination of factors limting and determining successful production.

The question at this stage may not be more one of method than of standard of achievement, of means which satisfy the critical exactions of the motive. While admittedly rather elementary and representing a preliminary stage, these methods and standards are becoming established and given credence to an extent which may delay putting more exacting ideals into effect, unless they are soon subjected to critical analysis. If the motive and the basis of discrimination remain latent they may be stifled. On the other hand, "every standing for a sound ideal sharpens discrimination and the appreciation of fineness."

As time goes on progress may be expected not only in the methodology but in clearer discrimination in classifying various types of activity. This will distinguish the research features more definitely from various forms of service which provide current facts of numbers and values and information on the temporary changes in status of the agricultural situation. These latter are useful and informing, although not to be confused with research; they give information about things as they are, if not understanding as to what produces them or what they signify. They may be regarded as business facts rather than the scientific or basic facts out of which knowledge is built.

The line between a shrewd guess and an actual fact, between speculation from indications and conclusion from sound evidence, may be much wider than is realized at the time. The aim in scientific research is to get not only reliable but permanent facts, those likely to occur again, with a knowledge of conditions which induce them. Scientific interest lies less often in an occurrence than in recurrence; that is, in something that may be expected and predicted after the necessary combination of circumstances to induce it is ascertained.

In the past much of the work which deals with economic and social relationships and with certain attitudes and aspects presented in the home has been of qualitative nature. A later tendency is in the direction of quantitative determinations but on a different basis. At present these determinations are sometimes very rough estimates, not based on records or approximations noted at the time, but statements from memory or guesses made after the lapse of considerable time. In such cases reliance is placed on large numbers, and it is assumed that the practice gives sufficiently accurate data for the purpose in view. But who knows? And admitting this to be true, the question follows whether it

is to be regarded as scientific research, and whether it meets the standards economic research should strive for if it is to reflect the method of science and attain its reliability.

These questions already are leading up to the study of methods with a view to subjecting them to critical examination and to developing means to meet the need of quantitative science. There is such a thing as misuse of tools in research, especially in the finer types of activity. As the workman can not turn out a piece of cabinetwork with a broadax, so the investigator can not rely on tools that are dull, crude, or ill adapted to the fine-grade product he seeks to produce. Attempts to sharpen these tools of research, to recognize their special uses and limitations, and to develop others better adapted to special purposes may mean much to the scientific character of the research. The "will to be definite" is a hopeful omen.

THE ARIZONA STATION

The generally bright picture of the year was marred by an unfortunate situation at the University of Arizona, which seriously affected the experiment station. This was the culmination of difficulties in the administration of the university which had been brewing for several years. The experiment station is a department of that institution and, with the college of agriculture, had been one of the storm centers.

The university administration which came into effect in September, 1922, early took action which radically disturbed the position and the relationships of the college of agriculture, affected its personnel, and confused its administration. There were notices of impending dismissals, some of which materialized or were forestalled by resignations. Gradually the experiment station was subjected to a type of supervision and intimate control by the executive which tended to disorganize its administration, and seriously interfered with the security of its research and the orderly conduct of its affairs.

As a result it became impossible for the Office of Experiment Stations to deal confidently with the director as the responsible officer in charge of the station, because it was evident that he was not given authority in carrying out plans and policies after they had been decided upon, and was not in position to protect the station interests. Even after budgets, allotments, and plans had been approved, the signing of all authorizations and requisitions for supplies, travel, and other needs of the station work was assumed by the president, who undertook to decide in individual cases whether or not they should be allowed. This frequently resulted in serious delay, causing annoyance and uncertainty, and even threatening the station work at important junctures.

Property of the experiment station to the value of about $2,000, bought with Federal funds for use on research projects, was arbitrarily diverted to other uses in another part of the university. With the coming of the Purnell fund, allotments for research from State sources were reduced, thus diminishing the benefits to be derived from the added Federal appropriation. This was in violation of the conditions under which the Purnell Act was secured, and of the admonition of the Secretary of Agriculture that the new fund should not be used to relieve a State of its previous responsibility. The situation was disclosed only after protracted delay in supplying the financial statements called for, and continued for two years.

An investigation of the university in the spring of 1926 engendered bitter personalities, and as an accompaniment the station work was practically suspended as far as provision for its continuance was concerned. There was prolonged delay in the required annual appointment of members of the faculty, including those of the station, with notable cases hanging in the balance. Only tentative budgets and assignment of working funds were available up to the close of the calendar year.

At critical stages the Federal funds were twice suspended, but were restored on more favorable reports in the desire to avoid unnecessary injury to the station and to give every opportunity for an amicable adjustment.

Ultimately, with a radical change in the board of regents, due to resignations and new appointments, the president of the university resigned, effective February 1, 1927, and a policy favorable to the interests of the experiment station was adopted. This should pave the way for the restoration of authority, security of personnel, and protection of the funds and activities in this field.

The station has a competent staff of workers who have demonstrated their ability to render effective service and who deserve much credit for the manner in which they remained at their posts in spite of harassing difficulties and delays in reappointment and in allotment of funds. With sympathetic and considerate management, the station should be able to regain the ground it has lost and serve effectively the varied agricultural interests of the State.

ESSENTIALS OF GOOD ADMINISTRATION

The Arizona instance is a new and unneeded evidence that few things are more dangerous to the well-being of a research institution than uncertainty and interference in the administration of its affairs. Investigators will maintain their zeal for research and manage to carry it on in the face of many unfavorable conditions if they are conscious of appreciation and moral support in what they are doing and of confidence in their strivings. They will forego much if there is regard for their position and an effort to make conditions as favorable as possible. But if there is lack of expressed appreciation of what research implies, a cramping of individuality, undue restriction and interference in small affairs, uncertainty of position and support, there will be not only loss of morale and of wholehearted loyalty, but also suppression of initiative and a dampening of enthusiasm, which are the mainsprings of productive, original effort. This does not imply necessity for coddling, but instead the encouragement of initiative and individual responsibility.

Research is more sensitive to adverse conditions than any other branch of university activity. This is because it is not routine or conventionalized but constructive and creative, an individual product of close mental application. Distractions and disturbances, uncertainty and apprehension, even though they do not actually touch those engaged in research, are adverse in their reflected effects; and when research becomes enveloped in strife and turmoil or the center of it, more concentration and devotion than most men possess are required to overcome such influences.

Research can not survive close supervision by many masters, and it can not flourish in a doubting, inhospitable environment which puts it constantly on the defensive. Latitude for initiative and responsibility must be granted if independence and originality are to be developed. This is true even though in individual cases the process may seem one of "muddling through" and may call for indulgence.

It is partly for these reasons that a director is provided at the head of the experiment station and large authority conferred upon him. He must be one who tempers desire and expectation with patience and tolerance, and hasty judgment with intelligent understanding. The policy of a station, the extent of its support, the general lines it shall pursue, the particular branches it shall stress—these are matters for determination by the governing and administrative authorities of the parent institution, acting in considerable measure on the advice and recommendations of the station director. With this approved background for general guidance, the administration ought then to be committed very largely to the executive officer of the station, with conference and advice where needed and a freedom of intercourse which will recognize the proper relationships to the institution as a whole.

From the nature of its work and its outside contacts, it is customary to confer a larger measure of responsibility on the station director than on the dean of a college, and to regard his staff as primarily responsible to him for their conduct and in their supervision. The responsibility for the success and the adequacy of the station within its means rests in the first instance upon him; the promotion of the morale of the station, passing upon proposed additions to the staff, supervision of station property and of funds assigned to it, including the issuing of requisitions and other necessary requirements, as well as the maintenance of outside contacts, are proper functions of the director's office. From his professional knowledge and his relationship to the investigations, the director is in better position than anyone else to determine the advisability of an expenditure under approved plans. Many important matters necessarily must be intrusted to him if he is to discharge his functions, and as the authorized head of the station he may safely be trusted to take up with his chief executive any unusual or doubtful item of procedure.

If the incumbent is not found competent, the remedy does not lie in the provision of checks and the curtailing

of authority, with divided responsibility. For a chief executive to attempt to deal in detail with station affairs, either regularly or intermittently, except through his director, is opposed to the principles of good administration. It is likely not only to destroy authority and influence, which are a main reliance in station management, but to be a source of irritation and uncertainty.

The station director is the officer with whom the Office of Experiment Stations uniformly deals in matters relating to the carrying out of plans and measures after they have been agreed upon. He is familiar with the department's interpretation of the Federal acts, and it is to him that the department looks to see that the spirit of these acts are preserved in the conduct of the station in his charge. The Federal funds are paid to the States in advance in order to avoid delays or embarrassment in the conduct of research from lack of funds. While the responsibility of the States for these funds is fully recognized and the usual precautions for safeguarding them are commended, it has not been considered that there was warrant for setting up regulations or procedure that would interfere with this relationsh'p.

The department's supervision of these funds is based in very large measure on confidence. An interruption of the established relationships and procedure is likely to be destructive of this confidence, and may become grounds for suspension of the Federal appropriations.

PERSONNEL

The number of station employees increased during the year from 2,530 to 2,754, or 9 per cent, owing largely to inauguration of new work under the Purnell Act. Of the total number, approximately one-half are employed exclusively in station work. The others have teaching or extension duties or both in addition to station work. While the proportion of part-time service for research is still large, there is evidence of a growing realization of the need of uninterrupted time for this purpose. This is often made possible by so grouping teaching and other duties that a particular part of the day or certain days of the week are made available for uninterrupted research. In other cases it has been found practicable to assign the other duties to a part of the year when they interfere least with the experimental work. This has proved very advantageous, especially in case of persons carrying several courses of instruction. Much of the station work is of a nature calling for continuous application, often with freedom to go out into the State to collect data or carry on studies, and makes time adjustment which adequately provides for such work imperative.

The relatively limited number of changes in personnel indicates that the stability among station workers shown by the previous year's report continues to a gratifying degree. The major changes and additions in personnel were as follows:

Changes in directorships.—S. B. Haskell, director of the Massachusetts station, was made acting head of the division of agriculture in the college. J. G. Lipman, director of the New Jersey stations, was granted leave of absence to attend a meeting of the executive committee of the International Committee of Soil Science, held at Groningen, Holland. R. Menéndez Ramos, director of the Insular experiment station of the Porto Rico Department of Agriculture, resigned in December, 1925, and was succeeded by F. A. Lopez Dominguez, chief of the division of chemistry of the station. In addition to his duties as director of the West Virginia station, H. G. Knight was made dean of the college of agriculture, succeeding G. R. Lyman, who died June 7, 1926. F. B. Morrison served as acting director at the Wisconsin station during the absence of the director, H. L. Russell, who spent the year in the Orient investigating educational work in physiological and biological sciences and their application to agriculture.

Other changes.—Appointments at the Alabama station included Georgia W. Burton, head of the research work in home economics; C. D. Miller, associate agricultural engineer; and W. H. Pierre, associate soils chemist.

W. T. McGeorge was appointed associate chemist at the Arizona station, succeeding C. N. Catlin, who died November 12, 1925. Margaret L. Cammack was appointed research specialist in home economics. J. G. Brown, plant pathologist of the station, returned from a year's sabbatic leave, spent at the University of Chicago.

W. H. Sachs, associate agronomist at the Arkansas station, resigned. A new substation for cotton experiments was established at Marianna in the eastern part of the State, and E. B.

Whitaker, a former extension worker, was placed in charge.

W. L. Howard, pomologist at the California station, was made also director of the branch of the college of agriculture at Davis. H. J. Webber, director of the citrus station at Riverside; C. M. Haring, veterinarian; and E. C. Voorhies, associate agricultural economist, returned to their duties at the station after a year's absence spent in study and travel abroad. R. L. Adams, head of the division of farm management, was granted a leave of absence to act as director of markets in the new State work.

At the Colorado station the resignation is noted of Nellie E. Goldthwaite, associate in home economics.

G. C. White, dairy husbandman at the Connecticut Storrs station, was made also dean of the division of agriculture in the college, succeeding W. L. Slate, jr., now the station director. E. O. Anderson was placed in charge of the dairy manufactures work. Margaret Schneider, statistician in poultry genetics, resigned.

H. L. Dozier was appointed entomologist at the Delaware station, effective August 15, and C. L. Benner, agricultural economist, assumed his duties September 1, 1925.

Among the appointments at the Florida station were those of C. V. Noble, head of the department of agricultural economics; Ouida D. Abbott, head of the department of home economics research; A. L. Shealy, veterinarian; and A. F. Camp, plant physiologist. E. F. Grossman succeeded G. D. Smith as associate entomologist in cotton-disease investigations.

W. G. Friedemann was appointed chemist at the Georgia station vice F. H. Smith, resigned. Susan J. Mathews and Catherine Newton, nutrition specialists of the Georgia State College of Agriculture, were added to the station staff for cooperative work. Frank Van Haltern was appointed associate botanist.

At the Idaho station H. C. Dale was appointed agricultural economist and Alan Dailey agricultural editor.

M. J. Dorsey was appointed chief in pomology at the Illinois station. C. L. Stewart was made chief of the newly established department of agricultural economics at this station, and L. J. Norton assistant chief. G. H. Dungan returned from the University of Wisconsin graduate school to take up the duties of assistant chief in crop production, and W. S. Brock of the extension division was added to the staff as assistant chief in systematic pomology. C. A. Garner was appointed associate in olericulture. G. E. Fager and A. C. Vogele, associates in horticulture, resigned.

A. G. Philips, head of the poultry department at the Indiana station, resigned May 1, 1926, and was succeeded by his associate, C. W. Carrick. H. R. Kraybill was appointed station and State chemist. F. C. Gaylord of the extension service was transferred to the station as associate in horticulture.

The Iowa station appointed J. A. Schulz of its staff as assistant chief in nutrition to succeed A. R. Lamb, resigned. Other resignations at this station were F. F. Sherwood, assistant chief of dairying, and H. J. Harper, assistant chief soil chemist.

P. M. Gilmer was appointed entomologist at the Kansas station and placed in charge of a laboratory in the southern part of the State, established in the spring of 1926 in cooperation with the Bureau of Entomology of this department, for the study of the codling moth. E. C. Converse was appointed meteorologist; W. H. Martin, associate in dairy manufactures; and F. L. Duley, associate in soils. J. H. Merrill, entomologist, resigned, and Eric Englund, agricultural economist, was granted a year's leave of absence for graduate study.

Mariel Hopkins was elected head of the department of home economics established September 1, 1925, at the Kentucky station, and W. A. Anderson succeeded P. H. Senn as microscopist in the department of feed control.

W. H. Dalrymple, for 29 years veterinarian at the Louisiana station and for a number of years the associate director, died July 17, 1925. W. G. Taggart, formerly in charge of the sugar station at Audubon Park, was elected assistant director of the stations, with residence at Baton Rouge. J. J. Munson, professor of mechanical engineering, was added to the station staff for research work in sugar engineering, and D. N. Barrow, of the extension service, was transferred to the station for seedling cane work to be done in cooperation with the Office of Sugar Plant Investigations of this department. Jane Dale was appointed October 1, 1925, to do research in vitamin work; this position she resigned in June, 1926. A. F. Kidder, agronomist, resigned June 15, 1926, to take up cotton-breeding work in Peru.

The Maine station appointed C. H. Merchant, professor of agricultural

economics in the college, as head of the new division established in the fall of 1925. F. V. Owen was appointed associate biologist in charge of the plant-breeding projects at the station.

The departments of animal and dairy husbandry at the Maryland station were consolidated and De Voe Meade, the animal husbandman, was made head of the new department. J. A. Gamble, dairy husbandman, resigned.

J. H. Frandsen was elected head of the departments of animal and dairy husbandry at the Massachusetts station, effective April 1, 1926, and C. R. Fellers, of the University of Washington, was appointed research professor of horticultural manufactures. Helen Knowlton, of the teaching staff, was transferred to the station for research work in home economics under the Purnell Act for the period from January 1 to June 30, 1926. Other transfers from teaching to research work included H. W. Yount in agricultural economics and A. W. Phillips in dairying. L. A. Bradley succeeded C. H. Werkman as assistant research professor of microbiology, and W. D. Whitcomb was appointed assistant research professor of entomology, effective September 1, 1925, with headquarters at the Market Garden Field Station, Waltham.

A. R. Marston was appointed agronomist at the substation for corn borer research work, recently established by the Michigan station at Monroe.

W. H. Alderman, chief of the division of horticulture at the Minnesota station, was given a year's leave of absence for a study of the fruit and vegetable methods in western and southern United States and as far north as British Columbia. Henry Schmitz, of the University of Idaho, became head of the division of forestry of the station, effective July 1, 1925.

J. N. Lipscomb relinquished his duties as agricultural economist at the Mississippi station to become dean of the school of agriculture. L. E. Long was appointed research economist, R. H. Smith research chemist, and J. M. Langston associate entomologist in the absence of H. W. Allen. Dorothy Dickins was made head of the new department of home economics research. K. U. Jones, veterinarian, resigned and was succeeded by C. B. Cain.

Eva M. Davis was appointed for research work in home economics at the Missouri station and F. L. Thomsen for marketing work in agricultural economics.

Jessie E. Richardson was elected head of the department of research in home economics at the Montana station and W. B. Mabee entomologist. The resignation was reported of E. L. Currier, head of the department of farm management.

The Nebraska station appointed Harold Hedges research professor of rural economics, effective August 1, 1925, and Greta Gray research associate professor of home economics. F. R. Nohavec, tractor testing engineer, resigned August 1, 1925.

F. B. Headley was appointed chief of the new department of farm development at the Nevada station.

F. S. Prince was appointed research specialist in soils and crops at the New Hampshire station.

H. F. Huber was relieved of his work in the department of horticulture and made assistant director of the New Jersey stations, effective January 1, 1926. W. H. Allen was appointed acting head of the poultry department vice G. W. Hervey, resigned.

At the New Mexico station A. L. Walker was placed in charge of the new department of agricultural economics, L. N. Berry succeeding him as head of the poultry department. H. W. Titus, nutrition chemist, resigned to take up work with the Bureau of Animal Industry of this department.

W. A. Stocking, dairy husbandman at the New York Cornell station, and acting director of the station during 1913–14, died February 3, 1926. W. W. Fisk, dairy husbandman at this station, was granted a leave of absence for 15 months, beginning April 1, 1926, for consulting work with commercial interests in western New York. Leave of absence for study and research work was granted to H. W. Riley, head of the department of agricultural engineering, L. A. Maynard in animal husbandry, C. H. Myers in plant breeding, W. I. Myers in agricultural economics, and G. W. Herrick in entomology.

At the New York State station O. M. Taylor, associate in research in horticulture, resigned, having completed 26 years of service. The resignation is also noted of R. L. Shriner, associate in research in biochemistry. Appointments in the rank of associate were C. B. Sayre in research horticulture and L. K. Jones in research plant pathology. A. C. Dahlberg was promoted from associate to chief in research in dairying.

F. A. Wolf, plant pathologist at the North Carolina station, resigned in July, 1925, to come to this department, and was succeeded by his associate, S. G. Lehman. R. F. Poole was appointed associate plant pathologist, and C. D. Grinnells dairy investigator. The new work in rural economics at the station was carried on by the following members of the teaching staff: C. C. Taylor, W. A. Anderson, A. J. Honeycutt, G. W. Forster, R. W. Green, and R. J. Saville.

E. A. Willson, of the North Dakota extension service, joined the station staff as rural organization specialist, and W. E. Brentzel was appointed plant pathologist, these appointments effective September 1, 1925. J. A. Munro was appointed entomologist, effective April 1, 1926, vice R. L. Webster, resigned.

At the Ohio station the department of agronomy was reorganized to include the sections of agronomy, chemistry, and soils, and R. M. Salter of the university was elected chief. The station also established departments of agricultural engineering, rural economics, and home economics. The heads of these respective departments in the university, G. W. McCuen, J. I. Falconer, and Faith R. Lanman, were placed in charge of the station work. W. J. Green, horticulturist and vice director of the station from 1883 to 1921, died October 12, 1925. H. A. Gossard, entomologist for the past 21 years, died December 18, 1925. The associate entomologist, J. S. Houser, was made chief of the department.

Fred Griffee was appointed agronomist at the Oklahoma station. F. B. Cross, associate in horticulture, was given leave for advanced study at the Michigan State College. His work was carried by E. D. Markwell, who later resigned.

W. T. Johnson was appointed poultry pathologist at the Oregon station and Maud M. Wilson, research home economist.

W. H. Tomhave, head of the animal husbandry work at the Pennsylvania station, was given a year's leave of absence to serve as secretary of the American Aberdeen-Angus Breeders' Association. F. P. Weaver, of the division of extension, became head of the department of agricultural economics, effective July 1, 1925. R. J. Miller was appointed associate in biological chemistry and research in poultry nutrition. W. T. Tapley, in vegetable gardening, resigned April 1, 1926, and was succeeded by J. E. Knott. Other resignations in the rank of associate were W. H. Martin in dairy manufactures and J. L. Horsfall in economic entomology. A. L. Patrick, associate soil technologist, was given leave for advanced study. F. D. Kern, who, during a leave of absence, had been acting as dean of the Porto Rico College of Agriculture, returned to his duties as head of the department of botany.

At the Rhode Island station the appointments included R. B. Corbett in agricultural economics and Mrs. Wilkie L. Hines in home economics. A. E. Stene resigned his duties as director of the extension service and joined the station staff as pomologist.

Franklin Sherman was appointed head of the department of entomology at the South Carolina station, effective September 15, 1925, succeeding F. H. Lathrop, resigned.

W. F. Kumlien, formerly extension director, was made head of the new department of rural sociology at the South Dakota station. Edith Pierson, dean of home economics in the college, and Anna O. Halgrim and Eloise B. Huskins, of the teaching force, were added to the station staff for research work in home economics. A. H. Kuhlman, associate animal husbandman, resigned June 30, 1926.

Margaret B. MacDonald was appointed biochemist at the Tennessee station.

W. B. Lanham succeeded A. T. Potts as chief in horticulture at the Texas station, and D. T. Killough was appointed agronomist in cotton breeding to succeed G. N. Stroman, resigned. R. E. Karper, superintendent of the Lubbock substation, was elected assistant director and agronomist in charge of small grain research, vice A. H. Leidigh, resigned. Fred Hale succeeded G. R. Warren as chief of the division of swine husbandry. L. P. Gabbard, who left the station in October, 1925, to go to the University of Wisconsin, returned in February, 1926, to resume his duties as chief of the division of farm and ranch economics. G. L. Crawford was appointed research marketing specialist.

Appointments at the Utah station included K. C. Ikeler as head of the animal husbandry department, P. V. Cardon in charge of research work in farm economics, and Mrs. Almeda P. Brown as special investigator to study rural standards of living in relation to food habits. I. M. Hawley, entomologist, resigned May 1, 1926, and

was succeeded by his associate, H. J. Pack. R. J. Becraft, in charge of range management investigations, was given leave to pursue ecological studies at the University of Chicago.

A. H. Robertson was appointed research dairy bacteriologist at the Vermont station, effective January 15, 1926.

At the Virginia station W. E. Garnett was appointed rural sociologist, effective August 1, 1925, and Ellen A. Reynolds was made head of the research work in home economics, effective July 1, 1925. F. W. Poos was appointed entomologist at the Truck station, Norfolk, assuming his duties March 20, 1926.

The division of farm management at the Washington station was enlarged and renamed the department of farm management and agricultural economics. George Severance, formerly in charge, was elected head of the new department. R. L. Webster succeeded A. L. Melander as head of the department of zoology and entomology, and Inez Arnquist was appointed research specialist in home management at the station, assuming her duties May 1, 1926. W. T. Shaw, zoologist, resigned. J. W. Kalkus, veterinarian, was made also superintendent of the Western Washington station at Puyallup, vice W. A. Linklater, resigned. C. E. Sawyer was appointed veterinarian in poultry research at this station.

R. B. Dustman was made chemist at the West Virginia station, the director, H. G. Knight, relinquishing his connection with this work.

Theodore Macklin, agricultural economist at the Wisconsin station, returned to his duties after a year spent in the study of the dairy industry of New Zealand.

T. J. Dunnewald was placed in charge of the soil survey work at the Wyoming station, and Elizabeth J. McKittrick, professor of home economics in the college, was added to the station staff for research work. E. C. Harrah, associate parasitologist, resigned.

ADDITIONS TO BUILDINGS AND EQUIPMENT

In some cases the station work has outgrown its accommodations, especially the housing facilities. States have been liberal with maintenance funds, but sometimes slow to provide necessary buildings to meet the growth in the station. In individual cases, new departments have been housed in very inadequate quarters. They have had to be content with what was available, pending appropriation for suitable buildings. The adaptation of the accommodations, even when in modern structures, has involved considerable outlay where the rooms had not been designed for laboratory purposes.

In one case, for example, the new work on vitamins was located in an old frame structure, formerly used as a house, where the only provision for heating was by oil stoves. This not only made the quarters uncomfortable for the workers but caused difficulty in keeping alive the rat colony used in the vitamin work. In some other instances the accommodations were crowded, subject to interruption by classes, or scattered to a degree that was inconvenient.

Such primitive conditions and handicaps are not confined to the newer departments, although they have suffered most often by being the latest comers. The States have provided many excellent buildings, in which the needs of the station work have been given special consideration; but the enlargement of activities under the Purnell Act has created a serious housing problem for many institutions which will need early attention.

The total value of additions to station buildings and equipment during the year was $1,363,722.11, as compared with $1,475,201 the previous year, of which $690,069.23 was for buildings used wholly or in part for station purposes. Some of the more important of the additions were as follows:

Construction of the new building for the college of agriculture at the University of Arkansas, for which a State appropriation of $300,000 was made a year ago, was under way and its occupancy expected by January 1, 1927. The building will be a unit structure, three stories high and 256 feet long, 58 feet wide, and with L's extending back 88 and 116 feet, and will provide accommodations for the dean, the agricultural editor, the agricultural library, a student room, a seed laboratory, and quarters for the departments of agronomy, horticulture, plant pathology, entomology, agricultural economics, and rural sociology. The cotton substation, for which $10,000 was also appropriated by the 1925 State legislature, was located at Marianna, in Lee County, where a tract of

160 acres was selected. Two other substations, one for rice and the other for truck crops, were provided for by the legislature, but were not established during the year.

A field station for the investigation of diseases of deciduous fruits was to be established in San Jose, Calif. The sum of $40,000 was made available to the station for the construction and equipment of the necessary buildings at Davis and in Berkeley to place the work of the division of poultry husbandry on a productive basis. Of this amount $10,000 was to be expended at Davis and $30,000 in Berkeley, the fundamental research work of the division being transferred to the latter place because of the more favorable climatic conditions existing there. Plans were made for the construction of a new building for agricultural engineering and irrigation investigations, for which $125,000 was available. The building will constitute the first unit of a group which will eventually house all activities of the two divisions.

Provision was made for the construction of a new greenhouse at the Connecticut State station, to be devoted chiefly to investigations in soils. A new research laboratory was equipped at Storrs for the department of animal diseases, providing the station with excellent facilities for bacteriological research.

Action by the Florida Legislature enabled the station to secure 320 acres of excellent land adjoining its present farm at Gainesville. A tract of 17 acres adjoining the tobacco substation at Quincy was also purchased and added to the lands available at that point. Plans were prepared for the erection of the first unit of the new agricultural building for which the State legislature appropriated $125,000, and it was anticipated that its completion would relieve materially the then congested condition of the station building.

A new experimental beef-cattle-feeding plant was completed at the Illinois station. This is a one-story brick and concrete structure containing seven experimental feeding lots, each 20 by 36 feet and having accommodations for 20 head of cattle. It was planned ultimately to connect this plant with the beef-cattle barn by the erection of an additional structure.

An addition to the Indiana station annex at Purdue University, costing $50,000, neared completion, which it was expected would provide additional office and laboratory space. The new horticultural building, for which the State legislature appropriated $150,000, was constructed. It contains classrooms and offices for the department, storage, laboratories, and an $8,000 refrigeration plant, where extensive investigations with fruits and vegetables may be carried on.

A contract was let for a new $250,000 library building at the Kansas State Agricultural College, which will provide increased facilities for the station library. Construction was begun on two additional units of the greenhouse, for which the State legislature made appropriation of $10,000. These units are to provide additional facilities for the departments of botany and agronomy and will be equipped with refrigeration for temperature control to be used especially in study of factors influencing the winterkilling and diseases of winter cereals.

Dedication exercises for the Western Kentucky substation were held at Princeton September 7, and for the Robinson substation at Quicksand September 11, 1925.

The Louisiana State University opened its fall term on the new campus, about 3 miles from the previous location. Approximately $4,000,000 had been spent in erecting new buildings, and the campus and farm lands occupy an area of about 2,000 acres. The sugar station was entirely transferred from Audubon Park, New Orleans, to new quarters on the university farm, and provision was made for experiments in the manufacture of beet sugar.

With a State appropriation of $6,000, a dwelling house for the plant foreman was being built on the Massachusetts station poultry range.

The new horticultural building of the Michigan State College was dedicated February 4. The college obtained 345 acres of additional land adjoining the college farm, 115 acres by purchase and the remainder by lease subject to purchase, making the land holdings of the college at East Lansing in the aggregate 1,593 acres.

The national egg-laying contest houses at the Missouri poultry station were replaced by 29 new and larger ones.

The agricultural building at Rutgers University was repaired and remodeled and a new system of roads was laid out on the agricultural campus with special appropriations provided by the New Jersey Legislature.

In order to provide facilities for investigations with range cattle, the New

Mexico station purchased a ranch and equipment on the Jornada Plains, about 22 miles north of State College. The ranch has two wells, is fenced, and contains about 40,000 acres.

Plans were made for the new building program of the college of agriculture of Cornell University. The rural engineering laboratories will have approximately 50 per cent more space than formerly. Four new greenhouses, which were being erected for the use of the vegetable gardening and floriculture departments, neared completion. Preparations were being made for the erection of the new library and plant industry buildings. Important additions were made to the collection of books on beekeeping.

At the Ohio station a new $35,000 beef cattle and sheep barn was under construction. Plans were being drawn for an animal industry building, fruit storage building, and sewage disposal plant.

The agricultural hall at Clemson College, S. C., which was burned, with a loss of approximately $200,000, was reconstructed in such a way as to provide room for a main library and a station library and at the same time furnish offices for the station workers.

The contract for a new library building at the South Dakota College of Agriculture was let, to cost about $200,000.

The corner stone of the new home economics building at the University of Tennessee was laid.

The Texas Technolgical College, a State institution located at Lubbock, formally opened its doors on October 1. A 40-acre tract of land adjoining the college buildings was set aside to be used for a testing ground for cotton demonstrations, etc. The college farm contains about 2,000 acres.

Completion of a new dairy manufactures building at the Washington station, to cost $275,000, was undertaken. The beef cattle barn, which was burned, was replaced by a new one of the same size and almost identical in plan. A special session of the legislature made appropriations to the college for the completion of James Wilson Hall, the agricultural building, a part of which had remained unfinished for a number of years.

Six experimental blueberry plats were established in Juneau County, Wis., to ascertain the possibilities of blueberry culture in central Wisconsin. Six demonstration forest plantations of 3 acres each were established in Portage, Wood, Juneau, Adams, Clark, and Eau Claire Counties.

THE INSULAR EXPERIMENT STATIONS

Agricultural experiment stations were maintained as heretofore in Alaska, Hawaii, Porto Rico, Guam, and the Virgin Islands under the administrative supervision of Walter H. Evans, Chief of the Division of Insular Stations of the Office of Experiment Stations.

These stations are maintained by direct appropriation to the Department of Agriculture for the purpose. The appropriations for the year ended June 30, 1926, were as follows: Alaska, $76,240; Hawaii, $54,940; Porto Rico, $56,460; Guam, $20,860; and Virgin Islands, $22,180. In addition, the Guam station was permitted to expend $3,847.50, the balance of the special appropriation for coconut scale control. Proceeds from sales amounting to $6,395.68 were deposited in the Treasury as miscellaneous receipts. The total sum available for the use of these stations was therefore $234,527.50.

There was no change in policy with regard to these stations, but because of limited funds for their support it was found necessary to suspend some important lines of work and curtail others.

All of the stations are endeavoring to develop types of agriculture suited to the local conditions, supplementing and in harmony with established industries, with the hope that their adoption will result in a more diversified and better balanced agriculture and a more prosperous and contented citizenship. While the objectives are to improve the respective communities, some of the results of the work of the stations have wide application and have been put into practice in similarly situated regions in other parts of the world.

Stations were maintained in Alaska at Sitka and Kodiak on the coast and at Fairbanks and Matanuska in the interior. The station at Rampart was closed and the work of that at Kodiak was restricted to the maintenance of a small herd of beef cattle on locally-produced forage and feed.

At the Sitka station, which is limited to horticultural investigations, particular attention was given to experiments in the production of new varieties of strawberries and potatoes and to bulb growing. This work has met

with a high degree of success. The growing of Jerusalem artichokes for feed and forage has also proved very successful at this station.

At the Matanuska station, yields of 30 bushels of wheat per acre, 20 of barley, and 40 of oats were obtained. Corn, however, was a failure. Progress in development of a Holstein-Galloway cross was reported.

The Fairbanks station had continued success in growing wheat, barley, and potatoes of station origin. A hardy Yak-Galloway cross has been obtained, but its value for meat and milk production has not yet been determined.

The Hawaii station continued its efforts to diversify the agriculture of the Territory. As a result of such efforts the pigeon pea and edible canna are being grown to a considerable extent on the various islands. The station has shown that some of the less productive sugar cane lands can be greatly improved by the growing of pigeon peas, which also give large yields of highly nutritious feed. The edible cana has been shown to have possibilities as a source of commercial starch. Hawaiian-grown vegetables have been found not to be deficient in mineral constituents, as has been claimed. Progress was made in testing and distributing a great variety of fruits, vegetables, and other crops. Extension work continued to be an important feature of the activities of the station, and it was not able to meet all the demands for this service.

The Porto Rico station gave special attention during the year to improvement of dairy cows and the testing and introduction of better forage crops, such as elephant or Napier grass, Guatemala grass, Uba cane, and velvet beans; breeding of sugar cane and corn, especially for high yields and disease resistance; fertilizer experiments with coffee and coconuts; management of pineapple soils; control of coconut bud rot and vanilla root rot; and animal parasites of domestic animals.

Among the more important lines of work of the Guam station were control of coconut scale and bud rot and the European corn borer; introduction of parasites of the cottony cushion scale, mealybugs, and aphids; experiments with forage plants and sweet potatoes; improvement of cattle, swine, and poultry; tests of copra meal as a feed for dairy cows and swine; introduction of improved fruits and vegetables; and extension and demonstration work.

The Virgin Islands station continued work with sugar cane seedlings, growing Bermuda onions for the New York market, sweet potato breeding, testing of various fruits and vegetables adapted to local conditions, and improvement of dairy cattle and poultry. Arrangements were made for cooperative and demonstration work on the islands of St. Thomas and St. John to encourage the growing of vegetables and other crops on these islands for local use.

SOME RESULTS OF RECENT STATION WORK

The following summary calls attention to some results of recent station work which appear to be of general interest and application, excluding those which at the present stage are purely of interest to the investigator. It is recognized that, even in this restricted sense, the summary is incomplete as a record of current station work, but it is hoped that it will at least serve to show that the scientific work of the stations is making definite contributions toward the practical solution of a great variety of important farm problems.

These reviews were prepared by members of the staff of Experiment Station Record as follows: W. H. Evans, plant physiology and plant diseases; H. M. Steece, plant genetics and field crops; George Haines, animal genetics, animal production, and dairying; R. W. Trullinger, soils and fertilizers, and agricultural engineering; J. W. Wellington, horticulture; W. A. Hooker, entomology and diseases of animals; Sybil L. Smith, foods and human nutrition; F. G. Harden, economics and sociology.

PLANT PHYSIOLOGY

Photoperiodism.—Continuing its investigations on the response of plants when exposed to periods of illumination corresponding to the longest and shortest day of the year, or some modification of the daily period of illumination, the Porto Rico station found that Bermuda onions and radishes were favored in their growth and development by the long day, whereas roselle, zinnia, poinsettia, *Tephrosia candida*, *Tithonia rotundifolia*, and Biloxi soy beans flowered and matured seed quickest under the short day illumination.

Salt relations of plants.—The Michigan station found that while certain combinations of salts in culture solutions gave better results than others, seasonal conditions influenced their requirements to a marked degree. As a result of several years' work it is claimed that the exact proportions in which salts are present is of little importance and the ratio of salts may vary widely without any appreciable effect on growth, provided all the essential salts are present in assimilable form. On the other hand, the New Jersey stations claim the nitrogen content of alfalfa varied with the proportion of the essential salt constituents in the soil. That calcium carbonate in neutral or alkaline conditions may not furnish enough calcium for the healthy growth of orange trees is reported by the California station. On the contrary, the continued taking up of potassium by plants grown under such circumstances was found to lead to unfavorable physiological conditions. The rôle of some of the so-called nonessential elements on plant growth has been investigated at the Kentucky station, and copper, manganese, nickel, and cobalt were commonly found in certain tissues of plants, the concentrations being greatest in seeds and other essential organs. The common occurrence of these elements is believed to suggest that they play an important part in the metabolic processes of plants. Experiments at the Rhode Island station show that manganous sulphate is a specific for the chlorosis of spinach growing on heavily limed soils. Badly yellowed plants, sprayed with a solution of manganous sulphate, 8 parts per million, quickly changed to a green color, grew well, and yielded 40 per cent more than check plants.

Experiments at the Michigan station with various vegetable crops grown on soils that had had their deficiencies corrected by the application of suitable fertilizers showed a higher total water content, more water per gram of dry weight, and a lower water requirement for such amendments. All tissues from such plants wilted less quickly than those from control plants. Nitrates were found to increase bound water and hydration capacity while potassium and phosphorus, especially the former, when used in connection with nitrates, decreased both bound water and hydration capacity. Raw sulphur used with nitrates did not reduce the nitrogen deficiency of tomato plants so much as did potassium and phosphorus.

Growth relations.—Few, if any, substances regarded as plant nutrients were found by the California station to overcome the basipetal development of buds or greatly diminished growth in the subapical portions of stems. Cutting back vertical shoots of lemons resulted in the production of new growth from the uppermost buds only. Wrapping, girdling, or notching above a bud had the same effect. Apical dominance is believed to be due to inhibitory substances produced by the plant, but injecting chemicals into dormant shoots did not increase apical growth. Sap concentration was found to exhibit a seasonal fluctuation varying inversely as to the rapidity of growth, the higher concentrations generally being found during the period of dormancy and the lowest when growth was most active. Blossoming of lemons occurred at the time when sap concentration in fruit-bearing wood was at its highest. Thrifty trees had a higher concentration at the time of setting fruit than unthrifty ones, and there was less June drop from thrifty trees. Pruning in some cases depressed sap concentration, but usually the effect was transitory.

The optimum temperature for the growth of roots and root hairs of citrus was found to be about 27° C., and the best soil reaction for the growth of sour orange seedlings was near pH 7.0, but no correlation was found between the reaction of the solution and root-hair production. The effect of the OH-ion concentration on the growth of citrus and walnut seedlings is said to be due to calcium starvation and not the concentration of the ions. Root growth was influenced more by the content of calcium in the solution than by the character of the anion with which the calcium ion was combined.

The New York State station reports investigations which indicate that straw contains a definite soluble compound that is toxic to the growth of plants. This is shown by the behavior of seedlings in cultures, germination and growth being inhibited even in the presence of an ample supply of available nitrogen.

Water relations.—The effect of hot desiccating winds was studied at the California station, and contrary to general belief older citrus leaves were found to lose moisture more rapidly than young ones. Spraying trees with a

heavy oil mixture was found to reduce transpiration and thus to offer some protection against leaf scorch due to dry, hot winds.

Metabolism studies.—A study of the nitrogen metabolism of apple leaves, spurs, and shoots is said by the Pennsylvania station to show that the water-soluble proteid is a single protein, or if more than one is present they must be very nearly alike in their amino acid constitution. This is considered very significant when investigating the carbohydrate-nitrogen ratio in relation to plant metabolism.

The Wisconsin station, collaborating with the United States Department of Agriculture, found an explanation for the belief that cool, fair weather is favorable to the storage of high percentages of sugar in the sugar beet. Reducing sugars were found to increase in the leaves with solar illumination, and temperature, as it approached 30° C., was a limiting factor in the increase of sugars. The fluctuation of reducing sugars in the leaves was found to parallel the storage of sugar in the roots. A high plane of reducing sugars, together with the presence of available nitrates, tended to the production of amino acids and rest-soluble nitrogen and a corresponding reduction of sugar in the storage organs.

Aging of plants.—Senescence and rejuvenation in plants were studied at the Vermont station, the potato plant being used as an example. Young cells were found to be filled with an abundance of protein material, especially in the nuclei and the large vacuoles. Old cells had less protein material in the nuclei, and it was in the form of granules, while the bulk of the cytoplasm was filled with large vacuoles. The aging of the cells is characterized by the disappearance of chromatin, the nucleoles become reduced in size and stain deeply, and the colloids in the cells are hydrolyzed, followed by the collapse and death of the cells. On the resumption of growth, as in the sprouting of the tuber, the rejuvenating cells free themselves of the accumulated starch, accumulate protein in the form of granules in the nucleus, and provide fat or fatlike substances in the cytoplasm to impregnate the newly formed cell walls.

Cell sap studies.—Investigations made by the Minnesota station, in collaboration with the United States Department of Agriculture, have shown differences in the leaf tissue fluids of Egyptian and upland types of cotton that appear to be specific for the varieties studied. Egyptian types of cotton take up more chlorides, and upland types more sulphates. The osmotic concentration and specific electrical conductivity of the Egyptian types were higher than for any upland types investigated. By applying these results and data relating to the soil solution it is believed it will be possible to predict the character of the crop that will be produced on any soil in a normal year.

GENETICS

PLANTS

Cytology of genus crosses.—In genus crosses studied by the Washington station, normal fertility was recovered in certain F_3 plants in both wheat × *Aegilops cylindrica* and wheat × rye, the chromosome number in the fertile plants being that of the female parent in each case. The reduction divisions were normal, but part of the male chromosomes appeared to be present. The divisions in the F_1 and F_2 generations were mostly very irregular, the gametic number varying from 0 to 35 and from 0 to 28, respectively. One plant supposed to be an F_1 of hybrid 128 × Aegilops had all the somatic characters of hybrid 128 but was practically sterile. Cytological examination indicated that its somatic cells had the haploid number (21) of chromosomes. Evidently the Aegilops pollen stimulated development of the seed without fusing with the embryo nucleus.

Chromosome variations in Crepis, Nicotiana, and tomatoes.—Crosses between species of Crepis differing in chromosome number at the California station gave rise in subsequent generations to new forms having chromosomes and characters from each parent. Cytological studies in several species indicated that knowledge of chromosome number, size, and shape may assist in systematic classification of species within a genus. Variations in the chromosome number in Nicotiana were discovered at this station. Haploids were found in two species, while in another species were two cases of an extra chromosome, these irregularities being correlated with genetic behavior. Cytological studies on varieties of tomatoes revealed chromosome irregularities giving rise to triploids and trisomics.

Fertility of lateral florets.—In certain barley hybrids at Cornell University lack of fertility of the side florets appeared to be a partly dominant char-

acter. There seemed to be an essential factor which differentiates the six and two rowed condition of fertility. A second factor when present with the first is responsible for various degrees of fertility of the side florets. The deficiens character seems due to a third factor for fertility of the side florets, and the deficiens form carries the recessive. The third factor is also assumed to be recessive in the six-rowed forms; its expression as absence of the side florets apparently can not occur without the first factor.

Buckwheat styles.—The West Virginia station found that long styles in buckwheat were recessive to short styles and controlled in their inheritance by a single factor difference.

Variability in citrus.—The extreme heterozygosity of citrus was indicated in a great variation occurring in the F_1 generation of interspecific and intergeneric crosses. Progeny from self-pollination were fewer and less vigorous than from crossing. Bud variations, found very common in citrus, are believed to arise by gene mutation or differential mitosis in single cells. Genic instability is deemed a characteristic of certain citrus forms. Polyembryony occurs generally from adventitious embryos developing from the proliferation of cells surrounding the embryo sac.

Endosperm characters in corn.—Investigations at the Connecticut State station of a number of new characters influencing the development of the corn endosperm revealed 13 distinct factors which arrest the development of the seed and cause it to be defective and incapable of normal growth and germination. Five additional factors may affect the nature of the stored food material in such a way that the seed can not attain a maximum development. Besides these 18 genetic factors, 9 other factors have appeared which stimulate certain functions prematurely, with equally disastrous consequences. Five complementary factors and two pairs of duplicate factors are involved in the maintenance of dormancy during development, the loss of any one or pair of these causing the seed to germinate prematurely with fatal results. A fully mature, normally developed, dormant, white, starchy seed seems to represent the cumulative action of 27 Mendelian factors of which the mode of inheritance is known.

A single main factor difference seemed responsible at the West Virginia station for the inheritance of a defective endosperm in corn. This factor difference appeared to be expressed in both endosperm and in the resultant plant as a whole.

Studies with corn at the Minnesota station indicated a linkage of the *Pr* factor with the *R* factor in linkage Group II. One of two yellow endosperm types differing from the usual yellow color was somewhat darker than pale yellow, and the other was a very pale yellow endosperm. Factors conditioning the development of these endosperm colors appeared to be located in Chromosome VIII.

Mosaic pericarp in corn.—Variations of mosaic pericarp studied at the Missouri station were found to be inherited and to form a series of multiple allelomorphs with the following order of dominance: Self-red, heavy mosaic pattern, light mosaic pattern, orange, and colorless.

Seedling characters in corn.—The character, purple plumule, observed in some of the seeds on several selfed ears of Indent corn at the Iowa station appeared to be due to the action of the dominant allelomorph of a single pair of genetic factors.

Five pale green types of corn seedlings were analyzed genetically, principally at Cornell University, all possible intercrosses being made. Three of the twisted types of corn seedlings studied, while similar in appearance, seemed genetically distinct, and were inherited as simple Mendelian recessives.

Golden plant color in corn.—A second factor for golden plant color appearing in Reid Yellow Dent strains, in cooperative studies by the Iowa station and this department, behaved as a simple Mendelian recessive as did the original factor for golden plant color. Their factor pairs were complementary in action but did not seem to be linked.

Giant corn.—A giant type of corn plant studied at the Missouri station was apparently due to genetic variation and not to chromosome duplication. The strain withstood inbreeding and drought and surpassed Commercial Whie corn in grain production.

Ear-row system of improving corn yields.—Continuous selection for high yield and low yield in an adapted unnamed corn variety by the Illinois station resulted in marked separation of two strains with respect to yield. Since the high yield strain did not significantly surpass a control strain propagated from the original stock by careful field selection without pedigreed breeding, it appeared that the yield

difference between the high and low strains was caused mainly through a decrease in the low yield strain. Continuous selection by means of the ear-row breeding plat could not be recommended as a method of increasing the yield of a well-adapted corn variety, whereas its yield might be maintained and perhaps somewhat increased by continuous mass selection.

Kafir characters.—Possible linkage between number of seed-bearing branches and length of seed-bearing branches and in some other combinations in kafir was indicated at the Texas station. Albinos and pure green seemed to differ by only a single factor,, whereas virescent whites and other classes appeared more complex.

Inheritance of earliness in oats crosses.—According to the behavior during a number of generations in certain oats crosses made by the Pennsylvania station, earliness, as measured by the time of heading, seemed due to a series of dominant factors which together had a cumulative effect.

False wild oats.—The Kansas station observed that the false wild types of Kanota oats did not seem to differ from normal Kanota in smut reaction, i. e., they apparently carry similar genetic factors for smut resistance.

Inheritance of tuber color in potatoes.—The inheritance of parti-color and suffused tuber color was studied at the Minnesota station, and the genetic constitution for tuber color for the Triumph, Early Ohio, and Red McCormick varieties was indicated.

Heredity in soy beans.—In inheritance studies with soy beans by the Illinois station the normal leaf was dominant in crosses between normal and narrow leaf types. In certain progenies segregating for hilum color (black and brown) and flower color (purple and white) there appears to be complete correlation between these characters. Hybrid beans in some crosses showed heterosis during the season in which the cross was made. The amount of mottling appeared to be determined to some extent at least by the genetic constitution of the material studied. It appears to be possible to isolate lines that exceed the average in oil content and lines that are lower than average. Soy bean of high-oil or high-protein content may be produced by the choice of existing high-oil or high-protein strains and perhaps by isolation of pure line strains within the variety and not by continuous selection.

Heredity in the tomato.—Observations at the Iowa station upon the progeny of crosses between tomato varieties contrasting sharply in color and size of fruits suggested that genes carrying flesh and skin color are independently inherited. Linkage was observed between color and size factors. The number of seed locules had practically no influence on fruit weight.

Inheritance in wheat.—A histological leaf study at the Nebraska station of wheat acclimated to various sources gave no consistent evidence of the inheritance of histological modifications induced by the environment.

Marquis spring wheat spring seeded is, according to the Washington station, highly resistant to bunt, but is comparatively susceptible when fall sown, whereas fall-sown Turkey winter wheat is highly resistant and spring sown is immune. The parental resistance seemed due to different factors. The factors causing resistance in the fall seedings were also operative in spring plantings. Resistance in Marquis × Turkey seemed due to two factors, that carried by Turkey being much more prepotent than that of Marquis. Partial dominance of spring habit and the inheritance of winter habit appeared to be controlled by multiple factors. Awns appeared to be inherited as a unit character. There seemed to be little, if any, linkage between awns and resistance.

ANIMALS

Station work in animal genetics tended toward studies of the inheritance of characters and groups of characters of more economic importance, especially questions of the physiology of reproduction.

Inheritance of color.—An analysis of results of studies of the inheritance of color in Shorthorn cattle at the Iowa station showed that there was an approximate 5.8 per cent error in the explanation of color on the basis of a mononhybrid series in which red is incompletely dominant to white and the heterozygote is roan. Spotting appeared to behave as a simple recessive to the solid color, while the inguinal spot is due to a separate factor.

Studies of the inheritance of color in guinea pigs by the Kansas station showed five new color factors designated as fading, a gene which fades yellow into cream several months after birth; darkening factor, a gene which makes cream individuals more intense with age; white tipping, a gene

which acts on chocolate hairs without affecting red hairs; black tipping, a gene acting on reds and dark-eyed whites at from 6 to 18 months after birth; and kodak, a gene tending to produce black or chocolate pigment in the hair of pink-eyed whites of the composition *pp* e^p— *CrCr*. Numerous matings between individuals carrying the complete extension factor *E*, partial extension e^p, and nonextension of black or chocolate pigment *e* have shown a considerable deficiency in the occurrence of the e^pe^p offspring.

The Kansas station also reported a new color factor designated as salmon eye in the guinea pig which behaves as a recessive to the normal and is evident only in the presence of the dominant allelomorph for pink eye. Certain modifying factors evidently influence the expression of salmon eye by reducing the pigment to such an extent that it resembles pink eye except for the differences in hair color. There was no evidence of linkage between pink eye and salmon eye.

Plumage color in poultry.—In studies of the inheritance of plumage color in Rhode Island Red fowls the Massachusetts station found three genes of particular concern to the breeder of standard color. *B* determines reddish-brown pigment and acts only in the presence of either or both of the other genes, *L* which is sex linked and modifies the distribution and intensity of brown pigment, and *E*, which is concerned with the distribution of melanic pigment. The popular shade of red in the male is dependent on the presence of *BB* and *L*—. *E* is responsible for smut in the undercolor and stippling in various portions of the body and should not be present in either males or females.

The typical Barred Rock feather pattern, according to studies at the Connecticut Storrs Station, is due to at least three genes, *B* for barring, E^m for extension of melanin to all parts of the plumage, and *S* for silver or inhibitor of buff or yellow pigment. By means of a recombination of the genes a sex-linked barring was produced in which the black crossbars of the Rock type were replaced by yellow, the individuals being genotypically $e^me^mB(b)ss$. Barring appeared to regulate both the black and yellow pigment. The white spaces in the black-white barring were not due to the action of the silver gene. Linkage between *B* and *S* was found to be very close in crosses of males heterozygous for the three factors with black, barred, and buff females. The E^m gene, however, prevents the development of yellow and white barring in the feathers.

In crosses between White Leghorns and Jersey Black Giants at the Kansas station linkage relations in the sex chromosome were indicated between the factors *B* barring, *R* rate of feathering, and *D* shank color, with nearly a maximum amount of crossing-over occurring between *B* and *R*, and *D* and *B*.

The inheritance of black, bronze, Narragansett, and Bourbon red in turkeys was found by the Missouri station to be due to a series of allelomorphs.

In further studies of the inheritance of characters in pigeons by the Wisconsin station the condition described as silky or lace feathers was found to be inherited as a sex-linked recessive.

In studies of shank color by the Connecticut Storrs station the inheritance of yellow, white, slate (blue, gray), and green (greenish black, willow, light green) were explained as due chiefly to factors *W*, which inhibits yellow in the epidermis and is present in birds with white, pinkish-white, pearl, blue, slate, and gray shanks, and *Y*, which inhibits melanic pigment in the dermis and is present in white, pearl, and yellow shanked fowls. *Y* is sex-linked and *W* is an autosomal character.

In further studies of breed crosses at the Rhode Island station the offspring of White Leghorns mated with White Brahmas were mostly white, though some were slightly rusty.

Inheritance in sheep and goats.—The F_2 generation lambs produced from the mating of purebred Hampshires and purebred Rambouillets at the Wyoming station tended to resemble one or the other of their purebred grandparents in body conformation more closely than did the F_1 parents. The F_1s showed a blend of the two breeds in body conformation as well as in density of fleece and diameter of fiber.

Results of experiments at the Oklahoma station, in which Shropshire, Dorset, Rambouillet, and Merino sheep were crossed, indicated that color, fineness of wool, fleece weight, smooth and faulty skin, and conformation were inherited in a blending manner. Fleece color was dominant to bareness and early breeding was partially dominant to late breeding in Dorsets selected for this character. Hornlessness of the Shropshire was incompletely dominant to the horned character of Dorsets.

Fineness of wool and faults in the skin were associated, as were dark face color and Shropshire characteristics.

In matings of Toggenburg bucks with graded up Mexican does the Texas station found that the polled condition was dominant over horns, and that the horns were better developed in males than in females, though the presence or absence of the condition was not sex linked or associated with sex. Wattles were due to a single dominant Mendelian factor and were not linked with sex or with the horned character. A strong tendency for kids to resemble their dams in all colors except white spotting was indicated, though definite modes of inheritance were not advanced. Solid white and, in general, black and extensive white spotting appeared to be epistatic to most other colors.

Twinning in cattle.—A study of the seasonal occurrence of twins by the Wisconsin station, based on the records of the American Hereford and Aberdeen Angus herdbooks, showed that the largest number of twin births occurred in August, with a tendency for larger numbers to occur during the late summer and fall, and the fewest numbers during March. The available data indicated that 0.98 per cent of births in dairy cattle were twins, but 8.84 per cent of the births in the Kansas station Holstein herd were twins. There was more frequent twinning among the offspring of certain bulls and among the dams related to certain bulls than in the herd in general. One bull produced 19.15 per cent of twins. The influence of the breeding of the dam was apparent, but did not appear to be as important as the breeding of the sire. Age, season, and production had no noticeable influence on the amount of twinning.

Inheritance of abnormalities.—Two types of rumplessness in fowls have been identified by the Connecticut Storrs station. One type was inherited as a single dominant Mendelian factor, but the other was accidental and nonhereditary. Anatomical studies of genetic and accidentally rumpless fowls indicated no significant difference. Owing to difficulties in mating, the rumpless fowls produced only a very small percentage of fertile eggs, though when rumpless females mated with normal males considerably larger percentages of fertile eggs were produced. The low fertility of this type of fowl was attributed to the mechanical difficulties in mating.

A factor *F* was found responsible for the production of normal feet and legs in mice at the Maine station, while its recessive caused an abnormal condition which appeared among the descendants of X-rayed mice. A modifying factor M^a influenced *ff* individuals in the direction of the normal, whereas M^a modified *ff* individuals in the opposite direction. In attempts to experimentally modify the germ plasm of albino rats two abnormal-eyed individuals were produced in one litter, which transmitted this characteristic to succeeding generations in an irregular manner. An abnormality of the teeth also later appeared in this line.

In matings of a hairless male rat with normal females at the Illinois station it was found that the hairless condition behaved as a simple recessive to the normal.

In experiments at the Kansas station no abnormalities in the development of the eyes of the offspring followed the introduction into pregnant rabbits of fowl serum containing precipitins of rabbit lens protein or from the direct injection of the lens protein into the rabbits.

Crossbreeding.—By double mating a Duroc-Jersey sow with Poland China and Duroc-Jersey boars at the Illinois station the 6 purebred Duroc-Jerseys produced in the litter averaged 3.23 pounds at birth and the 2 raised to 6 months of age averaged 185.5 pounds; the 4 Poland China-Duroc-Jersey crossbreds averaged 3.75 pounds at birth, and all 4 were raised to 6 months of age, at which time they averaged 235.2 pounds.

Inbreeding fowls was found by the Connecticut Storrs station to result in a decrease in vigor, but when different lines were crossed vigor was restored. Inbred females mated with their brothers produced eggs of which 40 per cent hatched, but when the same females in the following year were mated to males of other families 80 per cent of the eggs hatched. The outbred chicks grew better than those which were inbred.

Effect of age of dam on offspring.—In studies with mice at the Illinois station young dams produced smaller young than older mothers, but the difference in the young disappeared before maturity. The females coming in heat at the younger age proved to be most fertile.

Fertility.—In a study of the effect of vasectomy on the histology of the testicles of three boars the Wisconsin

station found that this operation had no influence on the histological structure, although a pronounced atrophy occurred in one of the animals. The testicles of the other two were somewhat distended with semen and showed the presence of many normal spermatozoa. This indicates that vasectomy does not cause degeneration of the seminiferous tubules in animals with closed inguinal canals.

Weekly intraperitoneal injections of 5-cubic centimeter doses of testicular extract into pregnant female guinea pigs at the Kansas station produced local pain, watering of the eyes, occasional coma, and frequent chronic peritonitis, and 25 per cent of the pregnancies terminated in abortions. The gonads of the injected animals showed marked degenerative changes with atrophy of the Graafian follicles and cyst formation. Young animals were sterile for as long as the injections were continued. Young born to injected pregnant females were normal, and the gonads of the males were normal, but the ovaries of the female young were shrunken and showed an overabundance of atresic follicles. Ovarian degeneration and the formation of cysts were rare in control animals injected with ovarian extract or amniotic fluid.

The effect of administration of Fowler's solution on the fertility of breeding animals was tested at the Illinois station by means of double matings with rabbits. Twice as many young were produced by males not receiving the toxic substance as by those to which it was administered. The average litter size of females receiving Fowler's solution was 5.3 as compared with 6.3, the average size before the solution was administered. Much sterility and a lack of disease resistance were manifest in animals which received the arsenic solution.

Oestrous cycle in the sow.—The oestrous cycle of 12 sows was found at the Missouri station to vary in different individuals from 18 to 25 days in length, with the period of oestrum running from 1 to 3 days. Leucocytes and epithelium cells were present in the vaginal smear in the greatest numbers during the week following heat and were fewest just before heat. The thickening of the walls of the vagina and uterus during oestrum correspond to the condition in other mammals. Studies of the ovaries indicated a gradual development of the follicles accompanied by the elimination of some at all stages in the nonpregnant sow. Ovulation evidently occurred between early and late oestrum.

SOILS AND FERTILIZERS

The number of station projects dealing with soils and fertilizers active during the past year was something over 500. These projects covered many subjects of fundamental importance to soil management and crop production. The specific studies of soils in relation to fertility and productiveness showed substantial growth and improvement.

Permeability.—Both lime and manure were found by the Oregon station to be effective in increasing the permeability of white land and silty clay loam.

The rate of percolation of water through heavy clay subsoils was appreciably increased by applications of calcium sulphate, and was actually decreased by certain applications of calcium carbonate in experiments at the Missouri station. The order of effectiveness in increasing percolation was calcium acid phosphate, a mixture of equal parts of calcium sulphate and calcium oxide, a mixture of equal parts of calcium sulphate and calcium carbonate, calcium sulphate, aluminum sulphate, and calcium oxide.

Flocculation of clay soils—The Missouri station found that liberal applications of rather insoluble salts such as calcium sulphate or calcium carbonate caused clay to remain flocculated for a long time under ordinary conditions of leaching. Different chemical treatments tended to produce floccules very different in nature in colloidal clay.

Soil moisture distribution.—According to studies at the Wisconsin station medium sand supplied crops with more moisture from light rains and showers than did fine sand or sandy loam when the precipitation came at a time when the initial moisture content of the soils was low. The greater water-holding capacity of sandy loam enabled it to store a sufficient supply from the heavier rains to produce the largest yields.

Soil moisture conservation.—Mulching, in addition to increasing the yield was found to save hand hoeing or cultivation of garden soils in experiments at the Ohio station. However, in a test with straw mulch in a light soil where all the straw was plowed under year after year the mulched plat gave unsatisfactory results.

Soil moisture losses from the upper 18 inches of soil were reduced to an

appreciable extent by an asphalt-coated paper covering, according to results reported by the California station. The paper covering also increased the mean temperature of the soil, hastened the time of warming, retarded the rate of cooling, and gave a narrower range between the maximum and minimum temperatures. The results were taken to indicate that while the use of the paper covering may conserve the moisture to some extent there is no indication that it will favorably affect the growth of crops.

The results of fallow tillage experiments at the Washington station indicated the importance of working the summer fallow reasonably early in the spring. The important feature appeared to be the establishment of the soil mulch before the weeds and volunteer grain made sufficient growth to materially reduce the soil moisture supply. Keeping the land free from weeds after it was plowed appeared to be as important as the early spring tillage.

The California station found that, under the conditions of the State, cultivation is of negligible value in conserving moisture in the soil except as such cultivation eliminates weed growth. Destruction of weeds was also found by the Texas station to be the principal consideration in intertillage operations. Just enough cultivation to control weeds effectively is considered the best kind of tillage and the ordinary cultivator the most effective implement for this purpose. The Ohio station considers frequent cultivation or stirring of garden soil in ordinary seasons unnecessary to obtain high production and, for some crops, to be actually harmful. Twenty-five per cent of the rainfall was stored in the soil by summer tillage in experiments at the Nebraska station. The heaviest losses in moisture storage were by direct evaporation from the upper soil immediately following a rain and before the water had penetrated into the soil. Cultivation to the greatest depth used increased the average moisture content of soil during the most critical period of the growth of corn, according to the Arkansas station. In experiments at the Oregon station, use of lime and manure increased the average moisture content of the soil during dry summer weather and decreased the water requirement per unit of dry matter produced.

Run-off and drainage losses.—The total quantity of salts lost in run-off water varied from 166.8 pounds per acre from plats in wheat and clover to 380.1 pounds per acre from plats spaded 4 inches deep in the spring and fallowed throughout the season, according to results reported by the Missouri station. Calcium and sulphur were lost in larger amounts than any of the other elements determined. The loss of potassium was relatively small, but amounted in several cases to considerably more than would ordinarily be applied in commercial fertilizer. The losses of magnesium, sodium, and phosphorus were too small to be of much practical importance. Surface run-off water was found not to be a great source of nitrate loss. The soluble salts from the fallow plats showed a higher percentage of inorganic material than did the soluble material from soil carrying a crop.

Applications of manure increased the losses of nitrate and potassium in drainage experiments at the Oregon station, while a rather heavy loss of calcium continued. Appreciable losses of phosphorus and rather heavy losses of sulphate were also observed, the latter being increased by manure applications.

Large quantities of calcium are removed from soil by drainage waters, according to the New York Cornell station, and generally amount to more than all other constituents together. The effect of cropping was to decrease the amount leached. Applications of ammonium salts, especially ammonium sulphate, markedly increased the calcium losses. The quantities of magnesium and potassium removed by drainage water were appreciable but not excessive. Nitrogen was removed almost entirely as nitrates. The loss from soil growing legumes appeared to be greater than from soil growing nonlegumes. The quantity of sulphur removed by drainage was comparatively large, but the quantity of phosphorus removed was practically negligible.

The leachings of calcium and magnesium from the subsurface soils similarly treated were found by the Tennessee station to be uniformly greater than those from the surface soils and the losses were greater with limestone than with dolomite, the difference decreasing with increasing fineness. Neither degree of fineness nor depth of incorporation of calcium hydroxide, limestone, or dolomite consistently influenced the total losses of sulphates and nitrates from soils.

Soil organic matter.—The Washington station found that the tendency of organic residues was to depress the

yield, especially of the straw, of winter wheat. The presence of a plentiful supply of available nitrogen was very noticeable in the early growth on soil to which alfalfa had been applied, and to a slightly less extent on soil to which sodium nitrate was applied. When added to sand and silt loam soils crimson clover increased plant growth in experiments at the Virginia station. Rye in a green state depressed plant growth in heavy clay soils but caused a slight increase in the more open soil types.

Green manures.—The evolution of carbon dioxide from green rye, oats, clover, and vetch mixed with soil was much greater than from the same materials air-dried. The Virginia station found that the legumes decomposed more rapidly than the nonlegumes when used as green manures. When green materials were allowed to decompose in soil no nitrates were detected after 10 days, whereas with air-dried materials nitrates were present, but in greater quantity under legume than under nonlegume treatment. Green manure cut between May 14 and May 28 showed the highest rate of decomposition.

The results of green manure rotation tests at the Mississippi station indicated a close relationship between bacterial counts and crop yields, and that legumes like Lespedeza can not build up soil fertility as rapidly as soy beans, crimson clover, or cowpeas.

The decomposition of timothy residues in soil was found by the New York Cornell station to extend over a longer period than that of clover residues. The greater content of nitrogen in the clover was held to account in large measure for the more rapid decomposition and the greater accumulation of nitrates in case of the clover.

Effect of straw.—The addition of oat straw did not appreciably affect the accumulation of nitrates in loam soils according to the results of studies by the Iowa station. Soils treated with straw alone yielded less than untreated soils. Where the straw was applied and turned under with the second growth of red closer, Hubam clover, or alfalfa, there was no retardation of nitrate accumulation. Oat straw when applied alone or in combination with clovers had no retarding effect on the growth and yield of corn. Straw when applied with clovers, ammonium sulphate, or sodium nitrate did not retard growth of other plants.

Nitrate accumulation.—The Illinois station found that the nitrification of both fall-plowed and spring-plowed sweet clover proceeded rapidly. The spring-plowed area was in better physical condition and required less labor in preparation than the fall-plowed area. Early plowing of clover in the spring gave a higher nitrate accumulation at an earlier date than plowing at a later date. Summer-plowed green sweet clover nitrified rapidly and large quantities of nitrates accumulated. Oats and rye proved efficient in converting much of the nitrate formed into organic matter, thus reducing losses, the oats being more effective in this respect than the rye. Nitrates were produced in much larger quantities in manured soil than in unmanured soil, in experiments at the Oklahoma station. Nitrification was greater under greenhouse conditions than outdoors for both manured and unmanured soils.

Nitrate production was comparatively slow at a temperature of 5° C., in experiments reported by the Nebraska station, but increased with temperature, reaching its maximum at 35° and ceasing altogether at 55°. This was taken to indicate that the prevailing temperature between the time of late plowing for winter wheat seed bed preparation and May 15 may be too low to supply adequate nitrate for the crop. Nitrate production was also found to be insignificant at moisture contents as low as the hygroscopic coefficient of the soil but increased with moisture content up to 1.25 times the moisture equivalent.

Alluvial sugar cane soils have a greater nitrifying capacity than loessial cotton soils as measured by the nitrification of dried blood and ammonium sulphate, according to the Louisiana stations. Plowing Melilotus into the soil caused an initial increase in nitrate accumulation but apparently did not affect the nitrifying power of the soil. Ground oyster shell increased the nitrifying power of cotton soil.

Varying depths of cultivation had little effect on the accumulation of nitrate nitrogen in a soil of rather open structure, according to the Arkansas station. The importance of winter cover crops as a means of reducing nitrate losses was indicated. The nitrate content of the soil was relatively low in the spring, but as the season advanced to late summer larger amounts of nitrates were found in the fallowed soils. There was little increase in the nitrate content of soils growing crops. Weeds drew heavily on the nitrate content of uncultivated soils.

An increase in the formation of nitrates from ammonium sulphate with increasing applications of lime to soils, which could be correlated with increased crop yields, was observed by the New Jersey stations. The final accumulations of unleached nitrates were the same, regardless of the form of lime used and of the fact that different forms of lime had a varying influence on the rate of nitrate formation. The nitrate-producing power of clay loam soil was found by the Oregon station to be depressed by sulphur alone, whereas the use of sulphur with lime stimulated the nitrate-producing power.

Nitrate accumulation was retarded by the addition of calcium sulphate in practically all of various soils tested by the New York Cornell station, but especially in an alkaline silt loam soil. It was also depressed rather markedly in a clay soil maintained at low moisture content and in silt loam soil to which 10 per cent of calcium carbonate had been added.

Mulched soil had much lower nitrifying efficiency than unmulched soil in experiments at the Missouri station. Nitrate accumulation was increased in the mulched soil by aeration and modification of soil structure by drying and remoistening. Removing the mulch markedly increased the nitrate accumulation after two months. Nitrate production in soils was found to be increased by spring tillage and decreased by crop growth. In the preparation of land for wheat, early-plowed soils contained more nitrate in the fall than did late-plowed soils. This seemed to be due to differences in weed growth. Studies on the effects of different soil treatments, long continued, upon bacterial activity in continuous wheat soils indicated the possibility that acid phosphate has an influence similar to that of lime as far as nitrate production is concerned.

Ammonia production.—The Oklahoma station found a general tendency for ammonification to increase from the use of either calcium oxide or calcium carbonate on very fine sandy loam and loam soils. Manure as a rule did not increase ammonification to any extent beyond that produced by lime, and seemed to have a depressing effect in some cases. Heavy liming caused greater ammonia production than light liming, and calcium oxide was, as a rule, slightly more favorable toward ammonification than calcium carbonate.

Acidity and soil bacteria.—The New York Cornell station found that soils may be or may become an unfavorable habitat for the various groups of legume bacteria and that these bacteria may largely or entirely disappear from the soil as it increases in acidity. These bacteria do not seem to be greatly influenced by the frequency of the host plant in the rotation, and it was found that in acid soils the addition of more bacteria resulted in the formation of a larger number of nodules per plant. The Missouri station reported evidence that a soil once inoculated with *Bacillus radicicola* will retain the organisms to reinoculate the host plant when it comes around in most of the regular crop rotations.

Alkali soils.—The Arizona station found that by applying gypsum as a corrective for black alkali in soils that contain no free carbon dioxide the amount of black alkali may be reduced to about 25 parts per million in the soil solution, but no lower. It was found advisable to leach the soil after an application of gypsum to remove the soluble salts and also to apply organic matter and to cultivate.

Alkali tolerance.—The toxicity of applications of various concentrations of sodium carbonate, sodium chloride, and sodium sulphate, singly and in different combinations, was found by the Idaho station to vary with successive crops of barley and oats. The toxicity of all such treatments was usually greatest with the first crop, and the majority of salt treatments stimulated the barley and oats yields in the second crop. In general the third crop showed toxic effects and the fourth crop yields tended to approach normal. Oats tolerated rather high concentrations of the combined alkali salts when the total salt content consisted of a low cencentration of each salt.

Lime and liming.—Chemically equivalent additions of ground limestone, dicalcium silicate, and calcium hydrate to soils deficient in basic materials increased the bacterial numbers in the soils in amounts varying with the forms of lime and with the soil, according to the results of studies reported by the New Jersey stations. Two acid soils showed an increased sulphate formation with an increased application of lime, but a well-limed soil showed very small increases in sulphate content with an increased lime addition. The rapidity of the

changes in the microbiological processes of the soil differed with the nature of the liming materials, although the final effects of chemically equivalent quantities of the several materials were the same.

The actual loss of calcium oxide from the normal plowed depth of soil is not necessarily confined to that removed by drainage, according to the Pennsylvania station, which also found that the rate of limestone decomposition is influenced by the soil reaction. Burnt lime did not maintain a high hydrogen-ion concentration. Lime had a tendency to reduce the water-soluble potassium, both when used alone and when used with manure. The Missouri station found that soils well supplied with soluble calcium usually produced good yields of clover and other legumes, even though the soil showed considerable acidity by the usual tests.

Liming of muck soils to complete neutrality did not produce a greater growth of corn than did moderate liming in experiments reported by the North Carolina station. The efficiency of fertilizers was found to be governed by the depth of liming. A greater benefit was observed from sodium nitrate and potash when the subsoil was limed than when the subsoil was acid. Heavy liming and deep plowing were accompanied by injurious effects in the field. Liming had no relation to the injurious effect of acid phosphate.

Liming was found by the Oregon station to increase nitrates in the soil and to stimulate their nitrifying and nitrogen-fixing powers. The principal effect of liming in cowpea-wheat experiments at the Tennessee station was to increase the amount of available soil nitrogen. Applications of burnt lime were not permanently harmful, and were considered to be justified as long as the crop increases obtained were profitable.

Different forms of lime gave similar results on a loam soil, in experiments at the Tennessee station. In general limestone was more extensively fixed than dolomite, especially when the coarser materials were used. It was found that the coarser the material the deeper should be the incorporation to insure disintegration, and that dolomite should be ground finer than limestone. Ten-mesh ground limestone was fully as effective as hydrated lime both in the first year and subsequently, in experiments at the Indiana station. No advantage was gained by grinding limestone any finer than 10 mesh. Marl gave results fully equal to both lime and ground limestone when applied in amounts of equal lime content. The value of limestone coarser than 20 mesh was found by the Illinois station to be very low as compared with finer stone. Light applications of limestone were found to give good results. On very acid soils a single large application gave excellent returns, closely approaching those obtained on plats where frequent applications were made.

No large differences were found by the Ohio station between the values of ground limestone and hydrated lime. There was no significant difference evident between the values of the increases produced by the high calcium and the magnesium limes either in the case of the limestones or the hydrated limes.

Sulphur.—The addition of sulphur to soil was found by the Utah station to increase the ammonifying and nitrifying power. It had no effect on nitrogen fixation. Sulphur failed to increase the yield of cane soils in experiments by the Porto Rico station. Calcium sulphate also failed to increase the yield on unlimed soils but doubled it on limed soils. It increased the yield produced by a complete fertilizer, but to a less extent than lime. The Oregon station found that the more finely sulphur is ground the more rapidly it is oxidized, and that sulphur ground to pass a 40-mesh sieve should contain enough fine material to satisfy the most urgent soil needs. The oxidation of sulphur was found to increase acidity or to neutralize alkalinity in soils and the acid produced brought calcium into solution. The rate of oxidation of the different forms of sulphur was also found by the Ohio station to depend upon the surface or fineness. Experiments by the Missouri station showed that crop growth on a semiarid soil which showed benefit from sulphur treatments retarded the formation of sulphate, whereas it increased the production of sulphate in humid soils. Humid soils are able to recuperate readily in their sulphate content, whereas some of the semiarid soils have difficulty in regaining enough sulphate for satisfactory growth after it has once been depleted. The Texas station found that sulphur had no significant effect on the yields of corn, cotton, and oats, and is not needed on

the heavy black limestone soils of central Texas.

Calcium sulphate.—The results of experiments with gypsum by the Iowa station indicated as a whole that on some fields very noticeable increases were obtained in the yields of oats and red clover by the use of gypsum, whereas on other fields no beneficial effects were obtained. However, very positive results were obtained from the use of gypsum on all of the alfalfa fields. Calcium sulphate was found by the New York Cornell station to have no effect on the growth of pasture grass, on the growth of chard plants in the greenhouse, or on the yield of cucumbers in the field. It slightly increased the water-holding ability of various soils.

Phosphate.—The Arkansas station found that crops are able to assimilate phosphorus added in the form of rock phosphate to acid soils. Corn showed a greater ability to utilize this material than other crops. The use of lime with rock phosphate on acid soils reduced the amount of phosphorus assimilated and the amount of phosphorus available to crops. The Ohio station found acid phosphate superior to raw rock phosphate as a phosphatic fertilizer. The Iowa station found that acid phosphate had a more decided effect on soil acidity than potassium or ammonium salts.

Liming was found by the Alabama station to increase the phosphorus content of the soil solution and of the extracts from soils receiving acid phosphate or basic slag. The influence of lime on the solubility of rock phosphate was not great, in some cases increasing it and in others reducing it. Liming decidedly depressed the solubility of the phosphorus in steamed bone meal.

Very fine grinding of rock phosphates appears to be unnecessary, according to the Illinois station. Slag and rock phosphates were found to be superior to acid and bone phosphates, although all of these forms gave appreciable increases in crop yields on brown silt loam soil. Both raw rock phosphate and steamed bone meal gave profitable returns when used with organic manures and limestone in both grain and livestock systems of farming, the latter showing some superiority. Acid phosphate gave better results with wheat on yellow-gray silt loam soil than rock phosphate, but the latter gave better results with corn.

Composting rock phosphate.—In experiments at the Delaware station, more than 50 per cent of the phosphorus of rock phosphate composted with oxidizing sulphur in high-grade muck became citrate soluble in 12 weeks, and in 30 weeks 85 per cent became soluble.

Nitrogen fertilizers.—Urea was found by the New Jersey stations to be a very desirable source of nitrogen and was very nearly equal to sodium nitrate in availability. In all cases it gave better results than ammonium sulphate. The rate of decomposition of urea was rapid in good soil but was much retarded in acid soil. Limestone applications to acid soils proportionately increased the rapidity of urea decomposition. The fertilizing value of garbage tankage was found to be very low. Its nitrogen content is low and very slowly available. Ammonium sulphate was found by the Iowa station to nitrify slowly in acid soil. Sodium nitrate and ammonium sulphate were found by the Mississippi station to be about equal as sources of nitrogen for cotton. Calcium cyanamide was not so efficient and cottonseed meal was even less so. The Arkansas station obtained similar results with sodium nitrate and ammonium sulphate on different crops, but the order of effectiveness of cottonseed meal and calcium cyanamide was reversed.

Farm manure.—The economic value of farm manure used as a fertilizer on Iowa soils is estimated by the Iowa station to be $1.97 per ton. Losses from manure due to improper storage and handling were found to amount to about one-half of its value on the average, and in many cases to three-fourths of its value.

Sewage sludge fertilizer.—In experiments at the Texas station corn fertilized with sewage sludge made very little gain over untreated plats when the sludge was applied at rates of from 500 to 2,000 pounds per acre either alone or in combination with 200 pounds of acid phosphate. Cotton similarly fertilized with sewage sludge showed a gain of from 15 to 20 per cent. The plats receiving from 1,500 to 2,000 pounds of sludge per acre and those receiving 1,000 pounds of sludge in combination with 200 pounds of acid phosphate produced the hightest yields.

Potash.—A comparison of various American potash fertilizers with standard imported potash by the Indiana station indicated that the German and domestic potashes gave approximately equal results. There was very little difference in the results from the sul-

phates, chlorides, and carbonates of potash. So far as could be determined, available commercial potashes do not now contain injurious quantities of borax.

Methods of applying fertilizers.—Moderate applications of noncaustic fertilizers were found by the Iowa station to produce the most economical returns of oats and wheat by the direct-contact-in-the-seed-rows method. The best yields with cyanamide came from broadcasting it 10 days in advance of the seeding. For large applications of noncaustic fertilizers it was apparently best to divide the total application between the drilled direct-contact-in-the-seed-rows method and the broadcast method. The best results were obtained with broadcast applications of fertilizers by disking the fertilizer thoroughly into the soil. In the fertilization of corn the hill method appeared equal to or even superior to the broadcast method if the fertilizer was not delivered into the hills in direct contact with the seed. The sides-of-hill method was preferable to the rear-of-hill method.

FIELD CROPS

CEREALS

Varietal variations.—A study at the New York Cornell station showed that the same names have been applied to varieties of oats and of barley distinct morphologically and to strains significantly different in yield. A name applied to a particular sample is of little value unless the exact source and the past performance be known. Physiological strains were found in most morphological varieties. Barley has a greater seasonal variation than oats, and probably is not so well adapted to New York conditions. Owing to their greater variability some varieties of oats and barley show greater possibilities in breeding work than others.

Lodging.—Lower percentage of carbohydrates and higher percentage of nitrogen and consequent lodging were induced experimentally at the Ohio station in oats and wheat by shading with cheese cloth, by increasing temperature, and by hypernutrition. These conditions indicate why lodging is most prevalent in warm, rainy, cloudy seasons and on rich soil where soil moisture and nitrates are abundant and shading is enhanced by a preponderance of vegetative growth.

Relation between yields, tillering, and other factors.—A decided positive correlation between yield and degree of tillering in wheat and barley was shown at the North Dakota station. The soil condition as affected by the rotation and immediate crop sequence was distinctly more active in influencing tillering than the space allotted per plant.

This station found no uniformly close relation between extent of tillering and yield of spring wheat, oats, and barley. Oats yielded most and tillered least of the three crops, and barley slightly exceeded wheat in both tillering and yield. Close relationships between rainfall and tillering and between tillering and yield were indicated.

Cereal hay.—Of various cereals tested by the California station barley appeared to be the most valuable hay, based on chemical analysis, but was second to wheat in nutritive effect. Wheat, under favorable circumstances, produced higher hay yields than the other cereals. Wild oats produced less hay than cultivated oats, but it was more palatable and nutritious.

Corn breeding and seed selection.—Experiments at the Nebraska station indicated that single and double corn crosses must be made anew each year, whereas seed of synthetic varieties may be selected in the same manner as seed of commercial varieties. Seed treatments recommended for seed corn did not prove beneficial under Nebraska conditions.

That each corn strain has a distinct average cob-breaking strength and that this is positively related with yield when strains are compared was indicated at the Illinois station. Certain relationships observed between cob color and yield might be of value in choosing seed for planting.

Curing seed corn.—Kiln drying at 112° F. lowered the germination of seed corn gathered in milk and soft dough stages at the Michigan station as compared with air drying, whereas corn in the hard dough stage did not seem to be affected, and subsequent yields showed a similar trend. A lower temperature and prolonged drying period reduced the damage by artificial heat. Corn harvested in early maturity stages and dried slowly in a moderate temperature (68°) will probably retain its germinability and yield equally as well as corn dried outdoors.

Corn stands and spacing.—In experiments at the Arkansas station on optimum numbers of corn plants for both favorable and adverse soil and moisture conditions, varieties similar in growth behaved similarly under uni-

form conditions. Tall, late-maturing varieties decreased more rapidly in yield with increasing numbers of stalks per acre than did shorter, earlier sorts. Barren stalks, few under favorable conditions, increased in percentage under adverse conditions, especially in higher spacing rates. Size of ears decreased in the higher rates. Fodder and stover and the stover: ear corn ratio increased with the planting rate under favorable conditions.

Fertilizers for corn.—Experiments by the Delaware station with corn on Sassafras silt loam from 1908 to 1923 showed the limiting fertility elements in order of significance to be potassium, phosphorus, and nitrogen. Of materials applied singly, potassium chloride increased the percentage of sound corn the most and with lime made further increase in yield and quality. Acid phosphate and potassium chloride seemed the best two-material combination from the viewpoint of yield.

Experiments by the Ohio station indicated that the consistent use of manure and acid phosphate on corn in a rotation including clover once in three or four years may maintain the yield at a level about double the State average.

Fertilizers applied in the hill on three soil types by the Wisconsin station increased the osmotic pressure of the sap of young corn plants, which in turn lowered the freezing temperature of the plant from 1 to 2° C., often enough to prevent plants from being frozen by ordinary late spring frosts.

Nutrition of selfed lines of corn.—Experiments by the Indiana station showed that the absorption abilities of selfed lines of corn and of crosses between them vary widely regarding certain essential mineral nutrients and the iron and aluminum salts in the soil solution. The absorption tendencies of the hybrid plants seemed to be associated with heterosis.

Rainfall and corn yields.—Considering the entire corn year, the Virginia station found that an increase in rainfall, within limits, was accompanied by an increase in corn yield. Alternate wet and dry periods seemed very favorable to corn production, low rainfall in May and July accompanied by high rainfall in June and August being conducive to high yields. Ample rainfall before earing time, in June, and also abundant rainfall during earing time, in August, appeared very beneficial.

Germination of feterita seed.—The rapid absorption of water by the seed coat of feterita was demonstrated by the Kansas station. The ability of the crop to germinate in a relatively dry seed bed indicates a reason for its adaptability to dry regions.

Selection of wheat.—Nothing seemed to be gained at the Nebraska station by continued selection within a pure line of winter wheat. The most productive strain grown pure appeared more profitable than a mixture of high-yielding strains.

Planting wheat.—No heritable change resulted from continuous planting of winter wheat at rates of 3, 5, and 8 pecks per acre at the Nebraska station. A wide range in seeding rate of winter wheat seemed feasible without a correspondingly marked effect upon yield.

Pasturing winter wheat.—The Nebraska station found that pasturing or mowing winter wheat in the spring (April) increased grain yields and reduced lodging, although in years without lodging pasturing reduced yields 32 per cent. Pasturing or mowing too close to the ground resulted in decided decreases in yield, probably due to injury to the developing spike, and also in a thinning of stand, reduction in mature height and straw weight, and delay in maturity.

Fertilizers for wheat.—Experiments with wheat, by the Ohio station, in 14 Ohio counties showed that acid phosphate used alone returned a profit in each test. On many soils profits yet larger could be expected from either potash-phosphoric acid mixtures or complete fertilizers.

Tillage of wheat.—Investigations at the Kansas station demonstrated that good yields accrued from growing wheat in a rotation and preparing the seed bed by plowing in July, subsequently cultivating when necessary to destroy weed growth.

Tillage and protein content of wheat.—The Kansas station found that the protein content in wheat is materially affected by the quantity of nitrates in the soil, which depends upon the tillage. Tillage treatments resulting in the most nitrates in the soil produced the most wheat and the highest protein percentage, and the flour from this wheat was also of superior quality. When applied in crop rotations, different tillage treatments greatly influenced the wheat yield and hence the quantity of protein per acre, but not the protein percentage and other factors indicative of milling quality.

Plats alternated with fallow and crop at the Montana station produced more spring and winter wheat per acre and contained more nitrate nitrogen during the cropped year and on an average more moisture to a depth of 3 feet than similar plats cropped continuously. The superiority of the fallowed plats suggested that nitrate nitrogen is a significant factor in controlling yields and quality of wheat in Montana.

Cultural practices and wheat quality.—The crude protein percentage in wheat grown at the Nebraska station in different years or from different planting dates did not indicate the baking value of the flour. While delayed planting, harvesting in early and late dough stages, and applications of manure altered grain yields, they did not give consistently superior milling and baking results, whereas early seed-bed preparation proved advantageous in both grain yield and baking strength.

Milling and baking quality of wheat.—Significant positive correlations were found at the North Dakota station between the protein content and baking strength of hard red spring wheat flour for 8 of 11 crop years, and between test weight and flour yield and a lesser correlation, varying with different crops, between test weight and color score of bread.

The Montana station observed that when wheat kernels 21 to 25 days from fertilization containing 50 to 56 per cent moisture were frozen, flour made therefrom was markedly reduced in quality. At 38 days from fertilization, however, and containing 34 per cent of moisture, frozen wheat gave a flour as good as unfrozen wheat at the same development stage. Immature wheat did not yield as good flour as the mature.

Dead wheat about 25 years old did not differ much from normal wheat in milling trials at the Kansas station, whereas the results of comparative baking tests showed the flour milled from dead wheat to be low in baking value. This flour in baking and the properties of its bread resembled that obtained from wheat injured by heating or by excessive germination.

LEGUMES

Germination of alfalfa seed.—The Utah station found that the ordinary laboratory germination test does not truly indicate the actual agricultural value of alfalfa seed. Discolored alfalfa seed germinated decidedly more poorly than bright, true colored seed, and plump seed surpassed shrunken seed. Bright yellow or bright olive-green seed were much more desirable than any other color. Scarified seed germinated better than unscarified seed, but contained more weak seedlings and moldy sprouts. Dry heat up to 85° C. applied for no longer than four hours increased germination by causing most of the hard seed to germinate. Discolored alfalfa seeds were considerably injured at much lower temperatures than were bright, mature seed.

Alfalfa root systems and soil structure.—In compact soil at the New York Cornell station all varieties and strains of alfalfa developed branch roots, whereas in open soil the taproots predominated. Grimm and common, as representatives of hardy and nonhardy alfalfas, respectively, appeared to have inherent root characteristics, and the nature of the soil structure to determine the degree of root branching.

Nitrogen content of alfalfa.—The Michigan station found that the nitrogen content of tops and roots of Grimm alfalfa exceeded that of Cossack or common at all periods. More nitrogen was present in the tops in the early than in the later development stages.

Alfalfa cutting.—Alfalfa hay cut twice a year was considerably less palatable and less nutritious than that cut three times, in experiments at the Iowa station.

Frequent cutting of alfalfa at the Arkansas station gave a higher average yield but had no material effect upon the condition of the stand. Cultivation with a heavy spike-toothed harrow after each cutting did not appear to affect either the weeds in alfalfa or the stand condition.

Fertilizers for alfalfa.—The Virginia station found 0.5 ton of burnt lime or 1 ton of ground limestone applied before each seeding to be ample for alfalfa in eastern Virginia. On both light and heavy soils 10 tons of manure per acre, supplemented by 400 pounds of acid phosphate, sufficed to insure good yields of alfalfa hay.

Sulphur for alfalfa.—According to results of the Minnesota station, sulphur fertilizers on alfalfa have failed to show any distinctly beneficial effects in many parts of the State, their place probably being limited to the northern sands and on these to alfalfa.

Alsike clover.—The Ohio station reported that alsike is not materially inferior to red clover in its root sys-

tem, and is very similar in the nitrogen content of both roots and tops at corresponding stages. It is much less subject to heaving than sweet clover, alfalfa, and red clover, and it presents no problem of regional adaptation.

Cold resistance of red clover.—Investigation at the Minnesota station demonstrated that the viability of red clover seeds with less moisture than 15 per cent of the dry weight is not affected by temperatures as low as —48° C. for short periods, whereas germination of red clover seeds with high moisture content is greatly impaired by low temperatures. Plants of the same clover variety varied with age in respect to killing temperatures. European or southern varieties generally proved less resistant to low temperature than those grown in northern areas of the United States.

Red clover seed.—Italian and Chilean red clovers were not suitable for the climatic conditions at the Indiana station, although central European sorts were considerably better. Northern European and Canadian clovers practically equaled the native strains. Excepting Italian seed, imported red clover seed compared favorably with the average of American-grown seed at the Pennsylvania station.

Sowing clover.—Optimum conditions with clovers at the Arkansas station included early seeding and seeding on a late snow on a surface honeycombed by a freeze and on the fresh soil following the planting of spring oats.

Climate and the clover crop.—The Ohio station found indications that under Ohio conditions an increase in clover yields follows, within limits, an increase in total rainfall and cloudiness for April, May, and June, an increase in total snowfall, and an increase in temperature for March and April, and a decrease in temperature for May and June.

Peanut fertilizers.—Application of ground limestone depressed the yields of peanuts at the Florida station, as was the situation with corn and velvet beans, whereas gypsum gave increases in all cases.

Soy bean nodule bacteria.—The existence of two biotypes was noted among eight strains of *Pseudomonas radicicola* of *Soja max* studied at the Wisconsin station. They appeared identical morphologically but not the same culturally or physiologically, and different varieties of soy beans did not benefit alike when inoculated with a type B strain of *P. radicicola* as with a type A strain.

The average nitrogen per nodule for three size groups in soy bean varieties at the Iowa station was closely related to the average weights of the small, medium, and large nodules. The number and different sizes of nodules appeared indicative of the relative inoculation efficiency of several cultures.

At the Illinois station no relation appeared to exist between the seed coat color of soy beans and their susceptibility to nodule bacteria infection. The total weight of nodules seemed to be a better index of the effectiveness of the bacteria than the number of nodules on a plant. Some soy bean varieties when inoculated apparently are more effective users of atmospheric nitrogen than others.

Soy bean fertilizers.—Experiments at the New Jersey stations indicated that soy beans may be grown on the same land continuously without nitrogenous fertilizers and the crop removed without seriously depleting the soil nitrogen. However, lime, phosphate, and potash should be applied regularly to offset losses through leaching and removal of crops.

Pollination of sweet clover.—Ordinarily white sweet clover is highly self-pollinated, and the same appears true of Hubam sweet clover, according to studies at the Minnesota station. Yellow sweet clover seemed either somewhat self-sterile or very sensitive to inclosure in nets.

Characteristics of sweet clover plants and seed.—The growth and flowering habits and seed characteristics of biennial white (*Melilotus alba*) and yellow (*M. officinalis*) sweet clovers have been studied in comparison at the North Dakota station. Mature seeds appeared to be normally hard coated and not to germinate promptly unless the coat is scratched or broken, whereas seeds somewhat immature germinated more readily. Much seed may become permeable by remaining on the plants over winter. Normal seeds stored as long as 15 years varied slightly in germinability, while heavily scarified seeds lost their vitality during the first year or two.

About three months' exposure to winter weather appeared necessary at the Iowa station for a high-percentage germination in sweet clover seed. Approximately 50 per cent of seeds stored dry subject to fluctuations of winter

temperatures open their coats the first year, and nearly all when exposed to two winters.

Cutting sweet clover.—Close cutting second-year growth of sweet clover after the stand has attained enough growth for hay resulted in the death of practically all plants at the Kentucky station. Cutting high, 5 to 10 inches, allowed more or less branch development, which varied inversely with the seeding rate and maturity stage and directly with the height of stubble left. Correctly handled, the crop may yield both pasture and hay, or pasture and seed, or pasture, hay, and seed the second year.

Composition of sweet clover.—Tops of biennial white sweet clover appeared to decrease in nitrogen, phosphorus, and sulphur with maturity the first season at the Illinois station, while the roots increased in nitrogen and apparently in other elements while increasing in dry matter. In the second season the roots increased slightly at first and then decreased, paralleling somewhat the concurrent decrease in the tops. Nitrogen was the outstanding element in both tops and roots at most sampling periods. Mineral elements were present in quantity generally in the order potassium, calcium, magnesium, sulphur, and phosphorus. The composition of sweet clover may be influenced considerably by applications of limestone, phosphorus, and potassium.

Spring seeded in small-grain crops by the Illinois station, biennial white sweet clover roots reached their maximum development in depth and bulk during the first fall, while tops attained their maximum bulk when the plant matured during the following summer. The crop approached its maximum total nitrogen per acre in the first fall and this remained practically constant during the early part of the following spring. The sweet clover contained at maturity the maximum amount of nitrogen per acre, largely in the coarse, heavy top growth. The highest percentage of nitrogen was contained in the roots during the fall and winter, while in the spring and summer growth the tops excelled.

Germination of legume seed.—Cooperative field trials by the Wisconsin station showed that with seedings made in late fall, midwinter, or very early spring and exposed to freezing and thawing for some time, hard seeds of alfalfa germinated very slightly, of sweet clover 40 or 45 per cent, and of red clover, white clover, and alsike about 15 or 20 per cent. Sown just after frost had left the soil, most hard alfalfa seeds germinated, while only about 10 or 15 per cent of those of red clover, white clover, alsike, and sweet clover germinated during the first season.

Longevity of the legume nodule organism.—Observations at the Illinois station showed that legume nodule organisms can survive for many years in an acid soil in situ but are quickly killed by air drying the soil. Seeds inoculated by the muddy-water method where an acid soil was used retained viable organisms for only a very few days and where a neutral soil was used for almost a year.

Winter resistance of legumes and their effect on truck crops.—The Rhode Island station found red clover superior to alfalfa, biennial sweet clover, and winter vetch in germination and growth when seeded in late summer or early fall, and it also withstood winter conditions best. Truck crops following red clover yielded more heavily than when grown after the three other legumes.

FIBER CROPS

Cotton seed and planting.—Early preparation of seed beds, delinting seed with sulphuric acid, cleaning and grading seed, and planting during the latter part of April were each conducive to enhanced yields of seed cotton at the North Carolina station.

Cottonseed delinted with sulphuric acid at the South Carolina station outyielded seed machine-delinted, untreated or rolled in sodium nitrate, gave perfect stands sooner, and the plants began blooming first and continued fruiting most rapidly early in the season. The first blooms and the heaviest fruiting occurred in the earliest plantings.

Preparation of land for cotton.—Experiments by the Texas station indicated that preparation of the seed bed to a medium depth fairly early produces best results with cotton on nonblowing soils, whereas on soils tending to blow later preparation was advisable.

Cotton spacing.—Closely spaced cotton excelled in experiments made by the South Carolina station and put on squares much faster than wider spaced stalks. Spacing had practically no effect on the developmental period of

the fruit. The highest cotton yields resulted where a stand of 18,000 to 20,000 stalks per acre was obtained.

Experiments over extended periods by the Texas station showed that the highest yields in general resulted from close and medium spacing, 6 to 21 inches, in the different parts of the State, except in eastern Texas, where comparatively wide spacing, 27 to 36 inches, gave the best results. Thinning cotton at the usual time generally produced larger yields than late or deferred thinning.

Cotton fertilizers and rotations.—Although a rotation of cotton, corn, oats, and peas tested by the South Carolina station seemed to maintain fertility as well as 1,000 pounds of 8–4–4 fertilizer applied to continuous cotton, a combination of systematic rotation and adequate fertilization appeared necessary for economical cotton production.

Fruiting studies with cotton.—According to the South Carolina station, a large or medium sized boll variety that fruits most rapidly early in the fruiting season yields most under boll weevil conditions. Cotton plants in dry soil seemed to fruit more rapidly early in the season and bolls matured sooner than those in wet soil. Defoliation did not hasten maturity or opening of the bolls.

Oil and protein content of cottonseed.—The Arkansas station found that high protein strains of cottonseed showed an increase of about 5 per cent above the average protein content, while their oil contents remained near average. The protein content tends to rise as oil content is reduced and remains quite constant during efforts to increase the oil content.

Flax retting.—The organisms predominating on flax fiber in studies at the Michigan station in cooperation with this department were found to attack the common carbohydrates and most of them to attack starch. Retting organisms seemed present on all normal flax straw studied in connection with pure culture flax retting. Flax straw could be sterilized by using air at 145° to 160° C. for three hours on two consecutive days. Sterilizing or heating flax straw before retting commercially was not advised because fibers become harsh and discolored when heated and the natural straw flora which aids retting may be destroyed. With an efficient operator, 30° seemed the best temperature for retting.

ROOT AND TUBER CROPS

Seed potatoes.—Evidence obtained by the Utah station in Cache Valley indicated that with Rural potatoes mosaic and other diseases can be avoided by hill selection.

The Nebraska station found that seed potatoes about equal in productiveness were produced in all parts of the State. Most "running out" of seed potatoes seemed primarily due to disease, environment being a secondary factor in providing conditions for infection and insect carriers. No lots of seed potatoes obtained were entirely free from all known virus diseases. As was also the case at the Utah station, greenhouse tuber indexing appeared entirely satisfactory for eliminating the various mosaic diseases.

Time of planting on dry land and quality of seed potatoes.—A time of planting study with potatoes on dry land in western Nebraska showed that tubers of lots planted on or before June 15 were practically matured by October 2. Tubers from early plantings were lighter in color, considerably more elongated, and scabbier than from lots planted later. More clean "seed size" tubers were produced with each later planting date.

Influence of soil type on seed potatoes.—Studies at Cornell University showed that potatoes grown on muck and upland soils had whiter flesh, greater mealiness, and better flavor than those from heavier soils. The lighter, better aerated soils employed seemed better for seed production than the heavier soils. Prejudice against muck-grown seed potatoes did not seem warranted.

Type of seed potatoes.—At the Nebraska station elongation of tubers as indicated by a reduced W/L ratio could be caused under controlled conditions by raising soil temperature, increasing soil moisture, and heavier soils. Place appeared to exert a decided effect and culture to have some influence on type. In type dry-land tubers generally surpass irrigated tubers, and in western Nebraska late plantings average better than early plantings. Such differences in type or shape in normal tubers are held to result from immediate environmental conditions of a temporary nature and not to affect yield.

Maturity of seed potatoes.—Observations at the Maryland station on Irish Cobbler tubers dug at six growth stages

from full bloom to the time when vines were brown and dry, indicated that the ripening and maturing processes in potatoes may continue during storage, so that by the end of the rest period immature potatoes large enough for seed have practically the same percentage composition and respiratory response as potatoes allowed to mature on the vine and stored similarly.

Dormancy and tuberization of potatoes.—Exposure of potato tubers to certain gaseous hydrocarbons and esters at the California station was found very effective in terminating the period of dormancy. A study of tuberization in the potato revealed a great accumulation of polysaccharides in the leaves and in the underground stems incidental to tuberization. While no starch was found in the leaves and above ground stems and little in the main underground stem or in the roots, the stolons were liberally supplied. Potato plants brought to tuberization in the warmer part of the summer formed no tubers and accumulated little carbohydrates.

Fertilizers for potatoes.—Potatoes receiving ammonium sulphate at the New Jersey stations yielded considerably less than those getting sodium nitrate, fish scrap, or tankage. However, tubers from sodium nitrate plats were severely injured by scab, while the reverse was true on ammonium sulphate plats.

Sweet potato fertilizers. — Fertilizers gave profitable returns with sweet potatoes at the Arkansas station only when phosphorus and nitrogen were used together. Applying all the fertilizer under the row before planting gave best results, whereas double applications or side dressings were unprofitable.

Sweet potatoes made noticeable response to fertilizers, including potash, at the Maryland station, plats receiving potassium chloride alone or with nitrogen or with nitrogen-phosphorus giving the largest increase.

Although total yields of Porto Rico sweet potatoes were only slightly affected by fertilizer treatments at the Missouri station, the percentages of marketable roots increased when potash fertilizers were used. The use of potash fertilizer was very definitely correlated with the percentage of carbohydrates. Commercial fertilizers seemed to affect in no way the keeping qualities of the sweet potato in storage.

SUGAR AND TOBACCO

Increasing sugar beet yields.—Field studies by the Montana station indicated that important factors contributing to the larger sugar beet yields were the application of barnyard manure, rotation with other intertilled crops, and the growth of alfalfa in the rotation for soil enrichment.

Sugar cane seedlings.—The Porto Rico station found that the best time for collection of sugar cane arrows varies with the locality and variety. Cane seed should be planted immediately after collection at about two arrows per square foot or slightly less than 0.25 inch in depth of arrow layer when wet down. A light dirt covering for the fuzz and watering germination flats to saturation once or twice a day gives good results. Seedlings grew much better in the greenhouse than in the open, and those remaining in germination flats until ready for the field grew decidedly better than those transplanted. For low mortality and ease of handling, 60- to 70-day old seedlings (3 to 5 inches in height) seemed best for transplanting.

Tobacco fertilizers.—Although average field applications of fertilizer salts carrying chlorine increased the chlorine content of Burley tobacco at the Kentucky station, this treatment was unimportant in respect to its effects on the tobacco quality.

Nicotine content of tobacco.—Applications of 300 pounds of ammonium sulphate at the Pennsylvania station tended to increase the nicotine content of *Nicotiana rustica* grown on light soils somewhat acid. Another 300 pounds added three weeks later resulted in a lowered nicotine content. An increased nicotine content always followed an increase in the sodium nitrate application.

The variation between individual untopped plants of certain tobacco selections at the New York State station was almost 1.5 per cent in the nicotine in the dry leaf. Topping has increased nicotine from 1.5 to 3.5 per cent in *N. rustica* and 1.5 to 2.5 per cent in *N. tabacum*. Fertilizing broadcast seeding of *N. rustica* increased nicotine slightly, especially when dried blood and urea in combination with potash were applied. Broadcast seeding generally gave much lower

nicotine values than did cultivated plants.

FORAGE AND PASTURES

Angleton grass.—The Texas staton found Angleton grass (*Andropogon annulatus*), introduced from India, to be valuable for pasture and hay and well adapted to the humid part of the Gulf Coastal Plains of Texas and to parts of the State having 30 inches or more of rainfall. It has succeeded on soils ranging from sandy loam to heavy clay.

Planting orchard grass.—Mixing clover with orchard grass seemed entirely practical for hay crops at the Arkansas station, but was not desirable for orchard grass seed crops. While no method of sowing orchard grass resulted in failure, spring seeding was much more reliable than fall seeding because of moisture conditions.

Planting Sudan grass.—Experiments at the Iowa station suggested seeding Sudan grass between May 15 and June 1. Seeding by broadcasting and harrowing or in narrow rows with a grain drill for hay or pasture was found most practical, with 15 to 20 pounds per acre for hay or pasture broadcasted or in narrow drills and for seed 10 pounds broadcasted or drilled in 8-inch rows as the most profitable seeding rates.

Cutting Sudan grass.—While more and better hay was obtained by cutting Sudan grass twice, curing difficulties and extra labor required with two cuttings led the Iowa station to recommend cutting only once and pasturing the aftermath. When two hay crops are desired, the first should probably be cut when the grass is heading and the second just before frost. The single crop may be cut when the seed is in the milk to soft dough stage, although Sudan grass may be cut from beginning of heading until in the hard dough stage. The optimum time of cutting for seed appeared to be when three-fourths of the seed are ripe and hard.

Reaction of grasses to chinch bug attack.—Native perennial species of grasses with harsh tissues, which comprise about 80 per cent of the native prairie grasses of Kansas, were found by the Kansas station to survive chinch bug injury and to show the most marked ability to recover, whereas most tender grasses were either severely injured or completely killed.

Bluegrass pastures.—Woodland pasture at the Ohio station had more weeds, yielded less dry matter, and pound for pound of actual bluegrass contained less total nutrients than the open pasture. The total carbohydrates found in the green material of the native woodland grass was 38 per cent less than in the native grass adjoining but grown in the open. The differences found in grass quality appeared to be due chiefly to variations in the light.

Burning off the old grass on established bluegrass pastures was found to be decidedly injurious at the Wisconsin station so far as the amount of growth was concerned.

ROTATIONS

Effects of previous crops.—The North Dakota station found that German millet residues by causing a deflocculated soil condition appear to have detrimentally affected and reduced the succeeding wheat yield in most seasons in a four-year rotation of corn, barley, millet, and wheat. Crop sequence studies suggested that while the crop immediately preceding wheat probably affects its yield most, some effect may be due to other crops in the rotation.

Effect of legumes on yields of succeeding crops.—When nitrogen was the limiting factor at the New York Cornell station, red clover surpassed timothy or rye in promoting the growth of succeeding nonlegumes during four years. In comparison with timothy alfalfa stubble and roots when plowed under produced greatly increased crops for three years after. Alfalfa was relatively more effective than red clover in fertilizing properties after the first year. Red clover, alsike clover, sweet clover, and alfalfa differed little in their effect on the yields of succeeding crops when nitrogen was the limiting factor.

WEEDS

Bindweed.—No consistent decrease in the number of bindweeds (wild morning glory) resulted from any of a number of chemical sprays applied at the Kansas station except on plats sprayed with sodium chlorate solution (12.5 and 25 per cent).

Canada thistle.—Frequent chemical analyses made throughout the year at the Iowa station showed that the least stored food is present in the root system of Canada thistle just before blooming, whereas the largest quantities are found in December. The roots absorb from the soil even when the

ground is frozen. The Ohio station found that Canada thistle can be exterminated by means of persistent and repeated cutting below the surface of the ground, clean cultivation, smother crops, and chemical sprays.

Russian thistle.—Delaying seeding until May 1 and destroying all weeds that start by thorough surface cultivation controlled the weeds in the crop at the North Montana substation. Seeding on May 1 with the weeds controlled gave as good or better wheat yields, and the grain quality averaged superior.

Water grass.—All season submergence to depths of from 6 to 8 inches was reported by the California station to be effective in the control of water grass on old rice fields.

Wild oats.—According to the Montana station, plats in the Judith Basin summer fallowed every second year and also those in a three-year rotation with a cultivated crop unmanured, had few or no weeds, nor were many weeds found in five and six year rotations which included sweet clover, alfalfa, or brome grass for several years. By destroying early weed growth on plats badly infested with wild oats with the duckfoot cultivator before spring seeding, a crop practically weed free could be grown that season. The California station found that fallowing, growing summer cultivated crops, or growing winter cover crops to be plowed under in April and fallowing the land for the remainder of the summer, materially reduced the amount of wild oats in the succeeding wheat crop, as compared with continuous wheat, but this control of wild oats appeared to be soon lost by again growing wheat continuously.

Wild onions.—The Kentucky station found that wild onions may be controlled by fall and spring breaking followed by disking and harrowing whenever these weeds appear until about June 15, when soy beans or corn are planted.

HORTICULTURE

Sterility in fruits.—That fruitfulness in apple varieties is influenced to a very considerable extent by rather local conditions was indicated in studies at the New York Cornell station, where Baldwin was found self-fruitful, contrary to results obtained at the Maine and Ohio stations. McIntosh was practically self-sterile, and Cortland fully self-sterile, yet the latter proved a satisfactory pollinizer for McIntosh. Pollen germination records of 24, 9, and 75 per cent for McIntosh, Baldwin, and Cortland show an absolute lack of correlation between pollen viability and fruitfulness. At the West Virginia station from 65° to 70° F. was found to be the optimum range for apple pollen tube growth upon agar sugar media. Pollen held at low temperatures with little or no growth developed normally when removed to a satisfactory temperature, but pollen taken from above optimum temperature failed to recover. Investigations at the Maryland station upon the cause of poor fruit set in the Arkansas apple showed this variety to be not only self-sterile but also intersterile with many varieties, including Grimes Golden, a sort with which it has been, unfortunately, often planted in commercial orchards. Where Jonathan and Delicious were interplanted with Arkansas good sets of fruit resulted. Variability in Arkansas set from year to year in a given orchard suggested that nutrient conditions within and without the trees apparently influenced the set of fruit. At the Arkansas station a positive correlation was observed between rapid growth of pollen tubes in the laboratory and the pollinating ability of the variety in the orchard.

European types of plums, the domesticas and damsons, were found by the Ohio station to be largely self-fruitful, but American, Japanese, and hybrid forms generally self-sterile. Sweet cherries were found to be mostly self-sterile and sour cherries self-fruitful. Lambert, King, and Napoleon sweet cherries were not only self-sterile but also intersterile. Similar studies at the Oregon station showed self-sterility to be the rule in most fruits and nuts grown there. Practically all varieties of filberts, chestnuts, cherries, pears, and apples were found largely self-sterile.

Fruit dropping.—Fallen fruits of the plum were found by the Delaware station to have a complete, although frequently much undersized, egg apparatus, thus showing that lack of pollination is not the primary cause of the physiological dropping. Observation on the fruit drop of three Jonathan trees treated very differently in respect to fertilizers indicated that the number and duration of the waves of dropping are in no manner connected with soil fertility. The Arkansas station found that ovules were fertilized in all fruits except those which dropped

within a few days after petal fall. Fruits with few seeds, those on weak spurs, and those in dense shade were the first to abscise. Early Richmond and Montmorency varieties of cherries examined by the Wisconsin station showed as high as 99 per cent of pollination in the fruits of the first drop, giving evidence that dropping is not associated with lack of pollination and leading to the conclusion that unfavorable nutritional conditions are the principal controlling factor in the dropping of cherries. This concept was supported by the fact that in years of light bloom the percentage of dropping fruits was considerably less.

Composition and productivity of apple spurs.—The Iowa station found high and low production to be associated, respectively, with low and high ratios of nitrogen to carbohydrates in the fruit spurs. At the Wisconsin station most abundant blossom-bud formation was found in those trees making an intermediate amount of growth and whose shoots and spurs contained an intermediate ratio of carbohydrates to nitrogen. Fruitfulness in the several branches of a single tree frequently varied as greatly as between branches of separate trees. Very slender growth in varieties normally making sturdy growth was indicative of low fruitfulness. That factors other than the ratio of carbohydrates to nitrogen are concerned in fruit-bud formation in the apple was indicated in studies at the New Hampshire station, which showed bearing spurs from sod-grown Baldwin trees to have essentially the same composition as that of nonbearing spurs from nitrated trees. It is suggested that metabolic activity in the developing fruit may have dominated bud development on the spur or that there may have been differences in the localization or nature of the food materials within the spur. The Maryland station found old growth of apple trees to be more variable in composition and less subject to seasonal changes than new growth. A high sugar and starch content was found in new spur growth at the time of flower bud differentiation. At this time nonbearing spurs were relatively high and bearing spurs relatively low in starch as compared with nitrogen.

Fruiting and exhaustion in the apple.—Studies at the Missouri station of the composition of bearing apple spurs throughout the growing season showed a definite movement of nitrogen to the fruit. When the fruits were half grown, over 80 per cent of the total nitrogen of the spur system was concentrated in the fruit. The fact that defoliated spurs were able to set and carry fruits to considerable size suggests that part of the nutrients may be taken from the general reserves of the trees, or at least farther back than the spur itself.

Biennial bearing in York Imperial.—Studies at the West Virginia station showed a marked tendency for old York Imperial trees to develop too many spurs, resulting in an overproduction of small size, inferior fruits, and generally in complete alternation of bearing. Applications of nitrogen accentuated this condition, but when used in connection with detailed pruning were helpful in restoring trees to a profitable condition. However, little evidence was obtained to indicate that biennial bearing in this variety can be overcome.

Sod v. tillage.—Studies by the Ohio station in various parts of the State show grass mulch supplemented with nitrogen to be highly effective, although not quite equal to tillage and cover crops. Deleterious effects of growing trees in unfertilized grass sod were observed at the New Hampshire station in a Baldwin apple orchard in which soil-management studies have been in progress for many years. Here the unfertilized trees in sod have steadily declined in vigor and yield and in some cases succumbed altogether. At the Iowa station it was found that apple trees maintained in a continuous bluegrass sod are decidedly lacking in vigor and fruitfulness. Studies conducted by the Pennsylvania station in various parts of the State and with young apple trees grown in iron cylinders under very carefully controlled conditions gave evidence that trees growing in sod may be maintained in a thrifty, vigorous condition if provided with liberal applications of nitrates.

Soil treatment and soil nitrates.—The Oregon station found a consistently higher percentage of nitrate nitrogen in cover-crop soils. Turned-under legumes apparently induced the formation of abundant nitrates and ammonia. At the California station adobe soils worked almost entirely with a plow had better soil texture and contained a higher percentage of nitrate nitrogen than did soils receiving ordinary tillage. At the Iowa station the growth of apple trees was found to be very closely correlated

with the amount of available nitrates in the soil.

Rest period in roots.—The Oregon station found growth of fruit trees to be practically continuous as long as the temperature of the soil remained above 32° F. and the water table kept below the roots. Submergence was more dangerous than low temperature, as water-logged rootlets failed to resume growth after the recession of the water.

Own-rooted apples.—Two stations, namely, Maryland and Iowa, reported definite progress in rooting apple cuttings. At the Maryland station it was found that in certain varieties deeply planted grafts composed of a long scion and a short seedling root had a definite tendency to send forth scion roots, especially if a fine wire was twisted above the union, causing partial girdling and the accumulation of carbohydrates. The Iowa station obtained similar results with midwestern varieties. Observations at the California station upon the rooting of apple grafts made with the point of union 2.5 and 5 inches above the lower end of the scion showed a tendency in certain varieties, namely, Northern Spy, Jonathan, McIntosh, and Delicious, for roots to develop on that section of the scion extending below the union. At the same time, very little tendency was noted for rooting to occur above the union, suggesting that the stock in some unknown way inhibits rooting in the scion.

Sources of nitrogen for the apple.—The Maryland station found that mature apple orchards show exhaustion from a lack of available nitrogen and that nitrate of soda is a more effective restoring agent than is ammonium sulphate. In growth, in foliage color, in fruitfulness, and in nitrogen content of the spurs there was a much more rapid response in nitrated than in sulphated trees. In Ohio conflicting results were obtained in comparing nitrate of soda and ammonium sulphate.

Picking maturity in apples.—From data taken at the Washington station upon chemical and physical changes taking place in Delicious and Jonathan apples harvested prior to, at the time of, and subsequent to commercial picking, it was concluded that determinations of hardness and of starch for Delicious and of hardness and acid for Jonathan may be helpful in estimating the best harvesting dates for these two varieties. Similar work at the Iowa station with Grimes Golden apples failed to show the mechanical tester to be of any value in determining maturity of the fruit while on the tree. Color changes in the skin combined with other indexes such as ease of separation from the spur and the ripening of fallen fruits were found of more value in estimating maturity.

Hardiness in the apple.—A well-defined correlation was found at the Iowa station between hardiness in established apple varieties and the quantity of aniline dyes absorbed from solution by ground tissue of twigs. The test is deemed of great potential value to breeders of hardy plants, for if perfected it would make possible the discarding of tender plant material without waiting for severe test winters.

Hardiness in plums.—Studies at the Minnesota station upon the progeny of crosses between species of plums differing widely in hardiness showed that hardy parents are essential to the production of hardy seedlings. In general, where both parents were hardy the progeny were all hardy, where both parents were tender the progeny were tender, and where the parents contrasted sharply in this characteristic gradations occurred in the progeny. *Prunus nigra* and *P. americana* were found to be of first quality as sources of hardy seedlings. In crosses between hardy and tender species a much larger proportion of the resulting seedlings were hardy when the hardy species was used as ovule parent.

Fertilizing and growth of peaches.—The Arkansas station found that nitrogen had a significantly beneficial influence on yield and growth of the peach, while phosphoric acid and potash had no effect. Examination of fertilized and unfertilized trees showed that increased yields were due primarily to increased length of the terminal growth, because as many fruit buds were formed per unit of length on unfertilized as on fertilized trees, and the fruits were practically of the same size in both groups. Measurements taken by the New Jersey stations upon the march of growth in Elberta peach fruits showed two periods of rapid accretion, one about 50 days after blossoming and the other as the fruits attained maturity. Fruits below a certain size on a given date failed to mature.

Selection in the grape.—The California station found no correlation between the

yield of the parent and of the asexual progeny of muscat grapes. In average yield, vines from low-yielding parents were practically equal to those of very high-yielding parents and showed similar variability. It is concluded that attempts to increase or perpetuate the fruitfulness of grapevines by bud selection are futile.

Growth and fruiting in the grape.—Records taken at the New York Cornell station upon the weight increase of the roots and the tops of fruiting and deflorated unpruned Concord vines showed reductions approximating 35 and 40 per cent, respectively, in the green weight of tops and of roots of fruiting as compared with nonfruiting vines. In most cases defloration had a marked tendency to increase leaf area. The total residue of dry matter from a given leaf area was much greater in fruiting than in deflorated vines. Studies at the California station showed that both fruiting and pruning had a depressing effect upon the growth of Vinifera grapevines, although that of fruiting was much less severe. Unpruned, part-crop vines yielded the largest and most numerous-berried clusters. Pruning markedly decreased the viability of the pollen.

Fruit-bud formation in pecan.—Studies at the Georgia station of pecan buds collected during the winter and early spring showed that differentiation of pistillate flowers occurs in terminal buds from February 15 to March 1. Pistillate blooms were found to develop rapidly and to reach a receptive condition in about two months after differentiation. Undeveloped pistillate flowers occurring at the time of pollination dropped without attaining a receptive condition. As the embryo sac is not mature at the time of pollination, it is concluded that fertilization does not take place immediately. Staminate blooms were found to be differentiated in lateral buds from 6 to 12 months before the pollen was ripe.

Fertilizers for pecans.—Experiments by the Florida station in pecan orchards on light soil showed the value of fertilizers, nitrogen and potash in particular, for this crop. The importance of adequate fertility for maintaining growth, especially in nuts borne upon young trees, was indicated.

Flower-bud formation in the cranberry.—That the cranberry conforms with other fruits in differentiating the flower buds the season preceding fruiting, was shown by the Massachusetts station. The first evidence of differentiation was found about the middle of August. The late removal of the winter flowage water delayed the resumption of flower-bud growth in the spring; yet subsequent development proceeded at such a rapid rate that the vines in the late-drained bogs were only a few days later in reaching full bloom than those in early drained bogs.

Changes in stored celery.—Observing that the sucrose increased steadily in stored celery while reducing sugars increased only during the first two weeks, the New Hampshire station concluded that sucrose must be closely associated with quality, which also constantly improves during the storage period. A material increase in the percentage of nitrogen in the inner stalks is believed due to translocation from the outer leaves, a conclusion confirmed by the New York Cornell station, which also found that pectic acid and pectin gradually increased during storage at the expense of the less soluble calcium pectate and pectose. Changes were less rapid in plants which had been grown in soil treated with phosphorus and potash in addition to nitrogen than in plants grown with nitrogen alone.

Sweet-corn breeding.—That the decrease in vigor generally accompanying self-pollination in sweet corn is due to a recombination of hereditary factors in a more or less pure homozygous condition rather than to any injurious effect of the process itself, was shown in studies at the Maine station. No significant differences were found in the height of plant or the weight of ear of F_1 plants whether inbred or crossed among themselves. The second generation of crosses between Golden Bantam and Black Mexican yielded black, yellow, and white kernels in the proportion of 12 : 3 : 1. The white segregates bred true, were of high quality, and valuable in crossing with other varieties. The progeny of crosses between inbred strains, especially those from different sources, were usually about twice as productive as the inbred parents and were frequently much more productive than the original parents.

Nutrients for the tomato.—The Rhode Island station found animal manures to be more effective than chemicals in increasing yields of greenhouse tomatoes. No changes in percentage composition corresponding to the excess or deficiency of different nutrient

elements was observed. In all cases tomato fruits were richer than their vines in all elements, especially potash.

Nitrate utilization by asparagus.—The New Jersey stations found an abundance of nitrates in the fibrous roots of asparagus plants growing in complete nutrients in continuous darkness, with none or very slight amounts in the large storage roots and only occasional traces in the bases of the shoots. There was a considerable loss of carbohydrates, leading to the suggestion that carbohydrates were probably used in the assimilation of nitrates.

Nutrients for cabbage.—Studies at the Michigan station showed a distinct ability on the part of cabbage to assimilate nutrients at various stages in its growth. However, maximum responses were obtained from fertilizers applied in the intermediate growth. Plants receiving nutrients in fractional doses matured more early heads than those receiving an equal amount of nutrients in a single application.

Blossoming habit in the watermelon.—The California station found that flowers of watermelon varieties may be placed in two groups, (1) those bearing purely pistillate and staminate blooms and (2) those bearing hermaphroditic blooms in place of the purely pistillate ones. When covered prior to anthesis these hermaphroditic blooms failed in the absence of hand pollination to set fruit, owing in all probability to the clinging of the pollen grains to the anthers.

Acid phospate for squashes.—The New Hampshire station found that acid phosphate stimulated the growth of squash vines and fruits throughout the entire growing season. The early response of squash to phosphorus was not, however, as marked as that of the tomato.

Detasseling sweet corn.—The New York Cornell station found that removing secondary stalks or suckers reduced both yield and growth of sweet corn. The size of the ears was not increased, nor was the time of ripening materially changed by this treatment.

DISEASES OF PLANTS

That the importance of plant diseases in agriculture, horticulture, and forestry is fully recognized by the experiment stations is shown by the fact that during the year 486 projects were reported as actively pursued, and nearly every station is represented in the list of projects. Some of the results of the investigations are given below.

INVESTIGATIONS

Corn diseases.—A bacterial disease of corn characterized by light or dark spotting of the leaves, especially the lower ones, and the rotting of the lower portions of the stalk, first reported by the Arkansas station in 1919 and since in other States, was found to be serious in Arkansas only during periods when temperature, humidity, and rainfall are higher than normal. The organism causing the disease, *Phytomonas dissolvens*, was observed to remain viable throughout the winter in infected stalks.

The yield of corn was found by the Maryland station to vary with the intensity of the internal discoloration of the cob, seed from ears not showing discoloration giving a more uniform stand, less fallen and broken stalks, and fewer prematurely killed plants than corn from ears with a greater amount of internal discoloration. The percentage of discoloration was almost completely eliminated in four years by planting each year seed from ears free from internal cob discoloration.

Cotton diseases.—More or less distinct strains of the cotton wilt fungus, *Fusarium vasinfectum*, are reported by the Arkansas station, which found that environmental conditions are important factors in the incidence of the disease.

Flax diseases.—The Minnesota station found that epidemics of flax rust may occur under normal conditions. Cool, moist weather, most favorable for the growth of flax, is also conducive to the development of the fungus *Melampsora lini*, the causal agent of the disease. The fungus also attacks wild flax, and such plants may be a source of infection, especially if perennial species should be attacked. Several physiological forms of flax rust have been recognized. The variety Argentine appears to be immune to all forms of the rust.

In continued investigations of flax wilt caused by *Fusarium lini*, the North Dakota station found that by crossing and selection strains of flax could be developed that are not only resistant to wilt but also to rust.

A recently introduced fungus, *Phlyctaena linicola*, has been shown by the North Dakota station, cooperating with the United States Department of Agriculture, to cause serious damage to fiber and seed flax when suitable

moisture conditions prevail. The disease occurs in North Dakota, South Dakota, Minnesota, and Michigan. Treatment of seed with formaldehyde, burning infested flax straw, and rotation of crops are recommended for its control.

Potato diseases.—Activities of the potato scab organism, *Actinomyces scabies*, are quite definitely limited by the acidity of the medium in which it is grown, according to the Minnesota station. Severe scab infection may be expected in soils ranging from pH 5.4 to strongly alkaline. When green rye plants at the rate of 50 tons per acre were incorporated with thoroughly infested soil, there was only a slight decrease in the soil acidity after 58 days, when early growth of the potato was most active and scab infection was in its critical stage. The beneficial effect of green rye is believed to be due to its influence in stimulating bacterial growth, which in turn restricts scab infection.

Potato wilt caused by *Verticillium alboatrum* is, according to the Oregon station, one of the most important factors in potato growing in the western part of that State. The disease is transmitted from crop to crop through the seed tubers, but an examination of the tubers does not always reveal the fungus, especially if infection takes place late in the season. The fungus spreads through the soil from the plant, but where infection occurs late in the season no wilting may occur.

The so-called degeneration diseases of the potato are receiving wide attention by the stations. Formerly grouped under the term mosaic or virus disease, about a dozen types of disease to which definite names are given are now recognized. The Oregon station considers rugose mosaic the most important degeneration disease of potatoes, but mild mosaic, witches' broom, leaf roll, spindle tuber, leaf-rolling mosaic, and giant hill are important also.

Spindle tuber was found by the Maine station, cooperating with the United States Department of Agriculture, to reduce the yield of Green Mountain potatoes in 1925 by 25 per cent, where completely infected seed tubers were planted; mild mosaic was equally as severe; and rugose mosaic reduced the yield by 60 per cent; whereas giant hill slightly increased the yield. Spreading of mosaic and spindle tuber from hill to hill in partly diseased stock is considered more important than spreading from field to field. Other insects than aphids have been found to spread the disease. Spindle tuber is said to spread less rapidly than mosaic where tuber selection is not practiced, and it is more readily reduced by tuber unit roguing. Leaf roll and rugose mosaic are easier to eliminate than mild mosaic.

The symptoms of degeneration diseases may be masked by temperature during growth, and the Wisconsin station found, under greenhouse conditions, that air temperature was the only factor that affected the amount and intensity of the symptoms on potato foliage. Relatively short exposures to temperature above 23° to 24° C. (73.5° to 75° F.) were sufficient to mask the symptoms of mosaic, the degree of masking depending upon the duration of the higher temperature and the age of the leaves. Masked symptoms always reappeared when the plants were subjected to lower temperatures. The time and duration of the masking are said to vary in different potato-producing regions.

Witches' broom, a degeneration disease, can, according to the Washington station, be transmitted to sound stock by grafting diseased tissue. Chlorosis, or calico, another disease of this type, spreads in the field, but negative results followed every attempt to infect plants by grafting or by allowing aphids from diseased plants to feed on sound ones. Giant hill was proved to be transmitted through the planting of selected tubers. Potatoes infected with witches' broom, leaf roll, rugose mosaic, and possibly with spindle tuber, start their sprouts from all eyes at the same time instead of progressively from the bud end as in normal tubers.

Each kind of plant subject to mosaic produces a definite type of the disease, according to the New York Cornell station, although mosaic from the potato may infect a wide range of plants. The green aphid (*Myzus persicae*) and the pink and green rose aphid (*Macrosiphum solanifolii*) were found to be the only insects transmitting the diseases to Bliss Triumph potatoes at the Idaho station. On account of its great susceptibility to mosaic the McCormick potato has proved practically worthless for planting under ordinary conditions, according to the Maryland station. The Maine station reports the possibility of apparently healthy potato plants transmitting a type of necrosis to other apparently healthy plants. Investigations of the North Dakota station are said to indicate the possibility of the

transmission of leaf curl, curly dwarf, and possibly mosaic through seed balls to seedling potatoes.

Rye diseases.—Investigations at the Indiana station of leaf rust, stem rust, and powdery mildew of rye have resulted in the segregation of plants of Abruzzi rye, that are highly resistant to each of the diseases. Resistance to the different diseases was found to be inherited independently, and when resistant plants were selfed various degrees of susceptibility and resistance were observed.

Soy bean diseases.—The North Carolina station has reported and described a half dozen diseases of soy bean that are common to North Carolina and the Orient. Several of these diseases are seed borne, but treating the seed with fungicides did not give control in some cases. The use of 2-year-old seed for planting reduced the amount of mildew and bacterial leaf spot.

Sweet potato diseases.—The Arkansas station has described a sweet potato mosaic infection that requires continuous growth for a year or more to secure its transmission. With such a long incubation period the disease is considered as not likely to be of importance outside the Gulf region where continuous growth is possible. Nancy Hall seems to be the only variety thus far infected, and the Tennessee station claims that the disease can be readily controlled by discarding for slip purposes all sweet potatoes from hills showing mosaic.

Pox of sweet potatoes was found by the Delaware station to be caused by an organism resembling *Actinomyces poolensis* and not by a slime mold as previously suspected. Drought is said to favor the disease, and soil reactions above pH 6 throughout the season are associated with an increased amount of pox. The New Jersey stations claim that both pox and scurf were increased by the addition of lime to the soil and reduced when sulphur was applied at the rate of 300 pounds per acre. The maximum of growth was made in soil showing a nearly neutral reaction.

Tobacco diseases.—Black root rot of tobacco was found by the Connecticut State station to be definitely associated with soil reaction. The most serious attacks occurred where the soil reaction was 6.4 or upward. The Massachusetts station found little black root rot in soils with a pH of 5.6, but as the soil became more acid, the amount of disease was found to increase.

Wheat diseases.—Most of the investigations on wheat diseases reported by the stations during the year dealt with the rusts. The Indiana station, cooperating with the Kansas station and the United States Department of Agriculture, found a number of strains of wheat resistant to leaf rust, *Puccinia triticina*, of barley resistant to *P. anomala*, of corn resistant to *P. sorghi*, and of rye resistant to *P. dispersa*. Twelve physiologic forms of leaf rust of wheat, two of leaf rust of rye, and two of leaf rust of barley are recognized. The presence of so many physiologic strains of the rusts is said to complicate breeding experiments for resistance. No one variety of wheat was found that was resistant to all the physiologic forms of leaf rust.

Investigations on the stem rust of wheat have been concerned chiefly with the overwintering of the rust, specialized forms, resistance of varieties of wheat to stem rust, and the eradication of barberries, which serve as the alternate host of the rust and as local centers for its spread to wheat crops. Kanred was the only variety of winter wheat that showed greater resistance to stem rust than Turkey Red at the Nebraska station. Some evidence was obtained indicating that Kanred has declined in its resistance since 1923. The Colorado station reports that urediniospores of stem rust survive the winter within the leaf sheaths of wild barley, but on account of their inability to escape they do not infect new plants in the spring. Evidence was obtained indicating the spread of rust from Texas and Oklahoma, but the invasion is usually about two weeks later than local infections from barberries. Where these have been destroyed, wheat escapes serious injury. The Michigan, Montana, North Dakota, and other stations have reported on the reduced epidemics of stem rust in their States following the eradication of the common barberry. Durum wheats have been shown to be more resistant to stem rust than the hard red spring wheats by several of the stations working in cooperation with the United States Department of Agriculture. Among the susceptible varieties the liability to rust infection is said to increase with the lateness of their maturity.

Yellow berry of wheat was found by the Oregon station to be directly due to nutritional disturbances result-

ing from an insufficient supply of nitrogen and other plant foods, and the relation of the occurrence of the trouble to dry farming is pointed out. It is thought that dry farming as now practiced can not indefinitely maintain a sufficiently high supply of nitrogen to control yellow berry.

Apple diseases.—The Missouri station found that it is very necessary to cover wounds where cankers have been cut out of apple trees, and, of the various materials tested, Tanglefoot proved the best protector and was not injurious to the growing tissues.

Root and crown injury is reported by the New York State station as quite general in apple orchards in the State. While a fungus, *Hypholoma sublateritum*, was found associated with the injury in many cases, the primary injury is believed to be due to the effect of low temperatures on immature tissues. Orchard management to prevent late growth is recommended to prevent injury

The Illinois blister canker of apple trees can be controlled, according to the Iowa station, by cutting out the cankers and painting the wounds with white lead paint to which corrosive sublimate is added at the rate of 0.5 ounce to 1 quart.

The causative organism of fire blight of apple and pear trees, *Bacillus amylovorus*, is stated by the Pennsylvania station to be carried over winter in an encysted form in hold-over cankers from whence new infections spread in the following season. Use of resistant varieties, cutting out of all cankers during the dormant season, and systems of cultivation and fertilization that will prevent excessive growth are recommended. Crab apple stocks should be avoided, as all are quite susceptible to infection. Growing trees on their own roots, where varieties are known not to carry the encysted form of bacteria, is recommended. The Wisconsin station reports that the fire blight bacteria can be carried over winter in apparently sound tissues adjacent to cankers, and that most of the early infection is brought about by rain-distributed bacteria from cankers and blighted twigs. Aphids and not bees are considered the principal agents in spreading the disease. Varietal differences in susceptibility are noted. In planting orchards preference should be given to the more resistant varieties. Cutting out blighted twigs and blight cankers and spraying for control of insect carriers are recommended as control measures. Very succulent growth of trees should be avoided.

A spot disease of King David apples is described by the Missouri station. The disease appears as small, circular, dark brown, sunken spots, which are most numerous on the side of the apple exposed to the sun. The cause of the disease has not been determined, but no parasitic organism has been found associated with the trouble.

A rotting of apple and prune roots caused by *Armillaria mellea* is widespread and very destructive in the Pacific Northwest, according to the Oregon station. The fungus spreads through the soil from decaying stumps and roots, and infection of apple and prune roots occurs through wounds or contact of diseased with healthy roots. A strain of the fungus that grows on oak roots is especially destructive to orchards in Oregon and adjacent regions.

Citrus diseases.—From a study of the effect of climatic factors on the occurrence of citrus canker and citrus scab, the Alabama station concludes that the period over which the canker remains active depends on the number of months having a mean temperature of 68° F. or above. It will probably be most severe in regions having an average temperature of 80° or higher for most months of the year. A deficiency of precipitation during the growing season is a limiting factor in its development. Citrus canker will be checked where early frosts destroy the late growth, and, if the frosts are severe, the infection will be practically eliminated through the defoliation of the trees. Citrus scab is inhibited in its occurrence by a mean monthly temperature of 78° or higher, and it is not likely to be severe in regions having an annual rainfall of 50 inches or less if well distributed throughout the year. Definite dry seasons are unfavorable for its development.

Crown gall of nursery stock.—Crown gall is one of the most serious problems in the growing of nursery stock. Examinations by the Wisconsin station of 175 trees from seven nurseries in four States, rejected on account of malformations, failed to show the presence of the crown gall organism (*Bacterium tumefaciens*) in any case. Malformations resembling crown gall and hairy root on apple root grafts, not due to *B. tumefaciens* but to over-

growths resulting from imperfect union of the stock and scion, which in turn bring about disturbed translocation of water and food, were noted frequently. Well-fitted grafts, proper wrapping, and avoidance of injury during cultivation are suggested as means for the prevention of this type of overgrowth. The Tennessee station also found aerial galls on apple and quince not of pathological origin but the result of abortive attempts on the part of the tree to form roots. The Wisconsin station found that tomato plants are readily infected by the crown gall organism. The largest galls were produced at growing temperatures of 22° C. (about 72° F.) for all degrees of moisture and at 60 per cent moisture for all degrees of temperature, within the temperature range of the organism. The optimum temperature for the growth of the organism was below 30° C., while the optimum temperature for tomato plant growth was higher. A somewhat similar range of conditions was found for crown gall development on raspberry plants.

Testing various species of Prunus to find crown gall-resistant stocks, the California station showed that some varieties of *P. domestica* and the wild species, *P. Pumila, P. besseyi, P. mume*, and others showed satisfactory resistance. *Amygdalus mira*, the smooth-pit peach of China, was also very resistant. Treating peach and other seedling roots with Bordeaux mixture prior to planting, a method considerably recommended, did not prevent infection.

Grape diseases.—A disease, black measles, of recent discovery in California is said by the station to be important in some of the grape-growing districts of the State. The disease is characterized by the spotted appearance of the leaves, canes, and fruit at the time the grapes are ripening. The cause has not been determined, but washing the vines with an arsenical solution is said to prevent it.

Anthracnose, black rot, and bitter rot of grapes are stated by the Delaware station to be carried over on the newly tied-up canes and not on the dried mummy grapes, as commonly believed. Suitable spraying formulas have been worked out for the control of these diseases, applications of which should begin when the new growth is about one-half inch long, and should continue at short intervals until the grapes are about the size of peas. About five applications are considered sufficient.

Peach diseases.—The overwintering of *Bacterium pruni* in fallen leaves is believed by the Illinois station to be the common source of initial infection of bacterial spot of peaches, cherries, and plums. Experiments at the Delaware station failed to produce yellows and little peach when peach trees were injected with infusions from diseased trees, and studies of the curculio as a carrier of the diseases gave negative results.

Cabbage diseases.—The Pennsylvania station recommends long rotations for the prevention of blackleg of cabbage and allied plants. Where this is impracticable and plantings are small, pouring about 0.5 pint of corrosive sublimate solution (1–1,000) about the plants at intervals of 10 days will afford some protection. The disease is also carried by the seed, and where possible disease-free seed should be used. Variability in susceptibility to blackleg infection is reported, and some strains of Pennsylvania Ballhead cabbage have been produced that show a high degree of resistance.

Strains of cabbage resistant to yellows due to *Fusarium conglutinans* have been successfully produced by the Wisconsin and other stations. Recent investigations of the Wisconsin station on the nature of resistance to yellows show that resistant plants have their roots invaded to a small degree by the fungus, but it fails to establish itself in the host tissues. It is suggested that certain sulphur compounds which commonly occur in cruciferous plants are more abundant in resistant than in susceptible plants and may account, in part at least, for the resistant factor. The Iowa station has developed a strain, Iocope, of Copenhagen Market cabbage that is very resistant to yellows.

Lettuce diseases.—The Colorado station found that anything tending to check rapid growth reduced susceptibility of lettuce to tipburn.

Pea diseases.—A bacterial disease of peas, caused by a strain of *Pseudomonas pisi*, has been described by the South Carolina station. A new disease of peas, black leaf, caused by *Fusicladium pisicola* has been recently reported by the Utah station. It is characterized by dark spots on the leaves, petioles, and tendrils. The disease is known to occur in Utah and

Idaho, where under favorable conditions it may cause considerable losses in peas grown for canning.

A number of causes of the rotting of pea roots have been reported. A survey by the Wisconsin station of 688 fields showed that *Aphanomyces euteiches* caused the most injury. The same situation is reported by the New Jersey stations, and the Delaware station found the fungus present in pea fields in 1925, but it was not a serious factor. The seriousness of the disease was found by the Wisconsin station to depend to a considerable extent on the number of consecutive crops of peas grown on the land. No type of soil was exempt from the fungus causing the disease, and it was found to persist in some soils for at least 10 years. Little evidence of varietal resistance to the fungus was found in experiments of the Wisconsin station. The New Jersey stations report that applications of lime, sulphur, and fertilizers were without effect in controlling pea root rot.

Pepper diseases.—Investigations at the Georgia station on pepper anthracnose indicated that disinfecting the seed will reduce seedling infection.

Tomato diseases.—Experiments at the Wisconsin station showed that the virus of the tomato mosaic may be transmitted to other species of plants, but that the type of disease is changed by transfer to a different host. The Indiana station found that soil and fertilizer conditions did not materially affect the severity of streak and mosaic. The California station found no variety or hybrid tomato that was able to withstand a severe attack of western yellow blight early in the season, but in attacks of moderate severity some dwarf varieties showed a fair degree of resistance.

Spray injury.—The injury to foliage due to spraying has been a subject of study at many stations, and many tests have been made to determine the conditions causing injury and means for avoiding damage. The New Jersey stations claim that the protective effect of calcium hydroxide in acid lead arsenic sprays is probably due to the fact that calcium arsenate is less toxic to foliage than the soluble arsenic acid of lead arsenic when used alone. The Michigan station reports injury to peach foliage following the application of fungicides or insecticides carrying lead arsenate. This is said to be particularly true when lime-sulphur is used with lead arsenate. When this combination is used, it is suggested that as many pounds of lime as of sulphur be employed.

Fumigation injury.—The Massachusetts station has sounded a warning against the use of hydrocyanic acid gas as a fumigant in greenhouses where the plants have been recently sprayed for disease control. Where diseases must be controlled by the use of Bordeaux mixture or other fungicides, fumigation with hydrocyanic acid gas should not follow for one or two days, or the cyanide should be abandoned and some tobacco fumigant employed.

CONTROL

Experiments reported within the last year have yielded significant data on the control of plant diseases. Some of the suggested treatments are given below.

Barley diseases.—Cooperative experiments between the Wisconsin station and the United States Department of Agriculture have shown that barley stripe can be effectively controlled by a number of new fungicides, mostly organic mercury compounds, used as liquid seed treatments. These were as efficient as the corrosive sublimate or formaldehyde treatments and did not cause injury to the seed, which is characteristic of the old methods.

Corn diseases.—The Kentucky station reports that the continued selection of smooth ears of corn reduced the amount of root rot in the field. Soaking seed corn in limewater for 20 hours reduced infection by some seed-borne organisms. Hot formaldehyde also reduced seed-borne infection, but neither treatment was effective against *Fusarium moniliforme.*

Cotton diseases.—The Texas station reports that rotations, which include bare fallow, longer than four years are necessary to control root rot due to *Ozonium omnivorum.* Sulphur applied at the rate of 10,000 pounds per acre reduced but did not eliminate root rot. The Florida station found that delinting seed with sulphuric acid not only reduced cotton wilt but greatly facilitated planting.

Oat diseases.—The New York State station reports that the best control of oat smut was by the formaldehyde sprinkle method of seed treatment. Copper sulphate and formaldehyde spray methods were nearly as good.

Potato diseases.—The Utah station claims the successful control of Rhizoctonia, scab, blackleg, and dry rot of

potatoes by treating the seed tubers with corrosive sublimate solution or formaldehyde. The Idaho station found that the efficiency of the treatments was increased by sprinkling the tubers and covering them for from 24 to 48 hours before treating them with corrosive sublimate or formaldehyde.

Investigations at the New Jersey, California, Kentucky, and other stations indicate that sulphur applied to the soil will control potato scab as a result of the increased acidity produced. The New Jersey stations suggest 600 pounds of sulphur and 600 pounds of raw rock phosphate per acre. The finer the sulphur the greater is its effectiveness.

Sweet potato diseases.—The Delaware station recommends from 300 to 400 pounds per acre of sulphur for the control of pox, soil stain, and soil rot. This treatment reduced black rot resulting through soil infection, but it had no effect on Fusarium wilt. Similar effective treatments were reported by the New Jersey stations, which recommend setting two or three plants per hill as a means of reducing stem-rot losses. The yield of merchantable sweet potatoes was not reduced by close setting and a full stand over the whole field was secured.

Sorghum diseases.—The Oklahoma station reports that treating sorghum seed with 4 ounces of copper carbonate or Bayer dust per bushel reduced smut and increased the stand of plants.

Wheat diseases.—Experiments at the California, Ohio, Minnesota, Oregon, Utah, Washington, and other stations have shown that treating seed wheat with 2 or 3 ounces of high-grade copper carbonate per bushel gave excellent control of stinking smut and did not injure germination. The Ohio station recommends adding 2 parts of powdered corrosive sublimate to 1 of the copper salt. A number of the newer mercury compounds are very favorably reported upon. For the control of loose smut of wheat several of the stations report having found nothing better than the hot water treatment.

Apple diseases.—For the control of bitter rot the Virginia station found the use of Bordeaux mixture effective. As a protection against apple rust this station recommends the removal of all cedar trees in regions of commercial apple growing. The cedar is an alternate host for the rust fungus, and spores are carried to a distance of 2 miles or more under favorable conditions.

Scab and blotch are two important diseases of the apple usually controlled by the same measures. Several stations, including those of Michigan, New Hampshire, New York (State), Ohio, and Virginia, have experimented with various means of control, including spraying and dusting. Experiments by the New Hampshire, Ohio, and Michigan stations have indicated the possibility of using weaker spray mixtures than those usually recommended without loss of efficiency. The New Hampshire station has recommended the use of 2–2–50 Bordeaux mixture. In cases of severe infection it has proved better than lime-sulphur used alone. Increasing the quantity of lime to five times that of the copper was found to prevent injury to susceptible varieties. The Ohio station reports that if spraying is done thoroughly scab and blotch can be controlled with Bordeaux mixture one-third to one-fourth the usual strength. Lime-sulphur also gave good control. The Michigan station tested various strengths of Bordeaux mixture and lime-sulphur solutions and found that with more thorough applications weaker sprays might be effectively used. The control depended on the extent to which foliage was covered. A correlation was found between the strength of the solution and the quantity of it applied. With careful spraying, strong solutions should be used in less quantity, while greater quantities of weak solutions are required to get the same amount of residue on the leaves. The important consideration is an even deposit of the fungicidal material over the leaves.

Experiments on apple scald, a very serious storage trouble, by the Indiana, Illinois, Missouri, and New York Cornell stations have shown that wrapping the apples in paraffin oiled paper prevented scald, and that shredded oiled paper was about as efficient as paper wraps. The Illinois station found that oiling the fruit prevented scald, but the fruit had an unpleasant flavor. No such objection to the use of oiled paper is reported.

Cabbage diseases.—The New York State station found the hot water treatment of the seed to be the most efficient method of preventing blackleg of cabbage and other cruciferous plants. The Pennsylvania station obtained good results with some of the new mercury fungicides for this purpose.

Celery diseases.—The New York Cornell station found that dusting celery

plants three or four times with copper-lime dust while still in the seed bed markedly decreased leaf blight and bacterial blight when the plants were transferred to the field.

Lettuce diseases.—Formaldehyde applied to the soil of the seed bed and coldframe reduced "drop" losses caused by Botrytis, Sclerotinia, and Rhizoctonia in experiments at the Pennsylvania station. The concentrated formaldehyde was applied to the soil, which was then thoroughly drenched with a hose. This reduced labor and was as effective as applications of 1 to 100 strength of the solution applied in the usual method with a watering pot.

Tomato diseases.—The Missouri station reports that the thorough incorporation, to a depth of 8 or 9 inches, of from 3 to 4 tons of lime per acre reduced tomato wilt.

Soil sterilization.—The Ohio station recommends steam sterilization of soil in coldframes and greenhouses as a means of control of many soil-borne diseases such as rosette and drop of lettuce, tomato wilt, and other diseases and nematodes on cucumbers, lettuce, and tomatoes. Formaldehyde was not effective for the control of wilts and nematodes of cucumbers and tomatoes.

Spraying *v.* dusting.—The Maine station found that, with the same number of applications of each, lime-sulphur dust was not as efficient as sprays for the control of apple scab. Copper dust did not control scab and caused considerable russeting of the fruit and leaf burning. The Delaware station reports as good control of scab by dusts as by liquid sprays, if the dusting is begun subsequent to the pink stage of the apple blossoms. Liquid sprays for earlier applications appear to be desirable.

Spraying with Bordeaux mixture was more effective for the control of celery blight than applications of fungicides in dust form, in experiments at the Connecticut State station. The superiority of spraying with Bordeaux mixture over dusting with copper-lime dust for the control of potato diseases is reported by the Michigan station, and the Minnesota station found that homemade Bordeaux mixture was more efficient and more economical for the control of potato diseases than any dust tested. The New Jersey stations report that little advantage followed the use of copper-lime dusts, but where Bordeaux mixture in liquid form was applied to potatoes there was an increase in production. The Ohio station found profitable increases of potatoes dusted with copper lime, but where the acreage warrants the use of power sprayers Bordeaux mixture is considered preferable. The Oregon station reports that dusting for the control of late blight was advantageous where it was not practicable to spray. In case of severe infection of tomatoes by leaf spot diseases the New Jersey stations found spraying with Bordeaux mixture was more efficient than dusting with copper lime.

In experiments on the adherence of sulphur in lime-sulphur sprays and dusts the New York State station found that from 89 to 93 per cent of the sulphur applied as dust was lost by mechanical means during the first week after application, while only from 34 to 75 per cent was lost from sprayed foliage during the same time. The addition of casein spreaders decreased loss during the first week, after which there was no further evident beneficial effect. In order to obtain the same effect, more of the active principle in the fungicide must be applied as dust than as spray. The New York Cornell station found that in field trials with potatoes 44 per cent more copper per unit applied was retained by sprayed foliage than by dusted. Where foliage was wet and both sprays and dusts were equally well applied, equal quantities of copper yielded about the same results.

ENTOMOLOGY

Oriental fruit moth.—This foreign invader, first discovered in America in 1916, has continued to spread and is the cause of great injury to the peach, plum, cherry, quince, and apple. At the Pennsylvania station the use of bait pails under orchard conditions reduced infestation by this pest nearly 50 per cent and the percentage of infested fruit nearly 25 per cent. A pail of approximately 1 gallon capacity, with a 6-inch diameter, filled with about 1 quart of bait (1 part molasses to 10 parts water, 1 ounce sodium arsenite per gallon of the mixture), gave a maximum catch and a minimum evaporation. Fermenting baits work best under orchard control conditions.

Codling moth control.—The Delaware station found Lily of Kent, Jonathan, and Missouri Pippin varieties of apples to have a decided resistance to attack of the codling moth, their fruit being uninjured while other varieties near

by were badly damaged. Old picking baskets and packing houses and sheds were found to be the most prolific sources of infestation and carry-over. The Colorado station found that under some conditions where spraying is not proving satisfactory the use of bands, orchard sanitation, and the picking of wormy fruit should be practiced. It was possible to trap large numbers of adult codling moths, and a fermenting sweetened apple juice proved to be a valuable attractant.

Fruit tree leaf roller.—A miscible type of oil gave better results on leaf roller eggs, in experiments at the Washington station, than any of the mechanical emulsions, a medium to light oil giving the best results. For control of the fruit tree leaf roller the Utah station recommends an 8 per cent miscible-oil emulsion or a 6 to 8 per cent lubricating-oil emulsion applied to apple trees in the spring before the buds begin to open.

San Jose scale control.—Lime-sulphur solution was found by the Massachusetts station to be more effective than the dry sulphides against the San Jose scale. Under Massachusetts conditions the 1 to 10 strength, if thoroughly applied, is highly efficient. Both the 2 and 5 per cent strengths of lubricating-oil emulsion gave perfect control of the San Jose scale at the Oregon station.

Citrus scale insect control.—The California station, in tests of kerosene and several different fractions of lubricating oils for citrus scale insect control, found a highly refined lubricating oil to be the most effective against red scale and the safest from the standpoint of oil injury. Fatty acids separated from soaps showed a much greater toxicity than the same amounts combined in the form of a soap. Mealybugs were satisfactorily killed on the trees by a 2 per cent lubricating oil. A quick-breaking emulsion gave the best results.

Strawberry root weevil control.—A poison bait was developed at the Washington station, to which the name weevilure is given, the distribution of which at the close of the berry harvest will satisfactorily, economically, and practically control the strawberry root weevils. This bait is prepared by sun- or oven-drying sliced apples, grinding them into pulp or granules, and stirring with a powdered arsenical or fluoride. This bait is broadcasted over the plants at the rate of 70 pounds to the acre.

Blackberry mite.—The Himalaya blackberry has been found by the California station to be injured by a mite *Eriophyes gracilis* which feeds near the bases of the drupelets and causes a red condition of the fruit at harvest time, known as redberry disease. The use of lime-sulphur or lubricating-oil emulsion gives satisfactory control of the pest.

Potato tuber worm.—The potato tuber worm, an outbreak of which occurred in three counties in eastern Virginia during the fall of 1923 and continued through 1924 and 1925, spreading northward and causing serious loss, was found by the Virginia Truck station to be identical with the splitworm of tobacco. Winter conditions in the infested district do not kill all of the insects, particularly where some protection is afforded. Another danger lies in the large numbers of worms carried through the winter in barrels of stored home-grown fall seed potatoes.

Eggplant insect control.—Dusting eggplants with arsenate of lead (1 pound) and hydrated lime (4 pounds) was found by the Illinois station to give the best insect control, but spraying with calcium arsenate (1.5 pounds) and lime (1 pound to 50 gallons) gave nearly as high yields.

Wireworm control.—Experiments at the Pennsylvania station indicated the successful control of wireworms on truck crops through the use of calcium cyanide as a soil fumigant. The use of a bait trap in the spring followed by an application of granular calcium cyanide before the crops were planted gave the most promising results. Wireworms were found by the Connecticut State station to be killed by cyanogas not only when in contact but through several inches of soil. Cyanogas killed tobacco plants when first put near them in the soil, but its toxic effect disappeared in a few days. Thus the wireworms that congregate in or close to the plants, leaving the more distant soil almost uninfested, can be destroyed and the plants be reset within a week. This gas seems to have no injurious effect on the quality of the cured leaf. At the Washington station calcium cyanide was found to be an effective soil fumigant for the wet-land wireworm, but was too expensive to be economical. The use of calcium cyanide for the destruction of the wireworm of irrigated land resulted in the destruction of from 85 to 95 per cent of the

worms in garden land with a population of approximately 400,000 per acre. The calcium cyanide was applied in early April a few inches from rows of trap crops planted 6 feet apart.

Striped cucumber beetle.—The fluosilicates of sodium and calcium were the only insecticides found effective by the Arkansas station in killing the striped cucumber beetle. In order to prevent injury to plants when used alone, it was diluted with hydrated lime. At the Tennessee station practically 100 per cent control was obtained through the use of commercial sodium fluosilicate. The striped cucumber beetle has been responsible in the last decade for a large reduction in the area devoted to cucurbits in Ohio through its attack on the roots and its dissemination of wilt disease. The Ohio and Illinois stations found that arsenate of lime with land plaster as a carrier, in the proportion of 1 part of the former to 20 of the latter, applied 12 times a season, gave excellent control.

Wheat stem sawfly.—The wheat stem sawfly, which was first described in 1887, and became a source of injury in 1921, has continued to increase in abundance and its ravages to increase in severity. It attacks wheat, rye, barley, and chess. The injury is caused by the larva, which, hatching from the egg deposited in the stem, works its way down, eating the tissue of the interior walls of the stem and at a point near the soil surface eats a V-shaped groove around the interior, thus nearly cutting the stem off.

Wheat stem maggot.—In South Dakota the wheat stem maggot is widely distributed, occurring wherever it can find certain native grasses or cultivated cereals in which to breed. Investigation by the station of its life history shows that there may be three generations a year, although in some cases only two occur. The pest was found to be rather heavily parasitized in the State, from 30 to 65 per cent of its numbers being destroyed in this way each year.

European corn borer.—This invading foreign pest is rapidly advancing into the great Corn Belt and is a serious menace to corn growing. Studies of it are under way at several stations. The New Hampshire station has found that the hibernating larva can withstand submergence from six to seven times as long as the active larva. This indicates that it is particularly resistant to unfavorable weather and particularly adapted to distribution by overflow and flood waters.

Alfalfa weevil.—In some fields as high as 50 per cent of this alfalfa pest was found by the Idaho station to be parasitized by the hymenopter *Bathyplectis curculionis*.

Sugar cane borer control.—In sugar cane borer control work in which dusts were applied by airplane, the Louisiana station found the use of sodium fluosilicate to give the best results, more than 90 per cent of the larvae of all sizes being found dead on the leaves and within the stalks four or five days after the dust was applied.

Seed corn maggot.—Investigations extending over three years at the Minnesota station have shown a close association between the seed corn maggot and potato blackleg. The larvae were found to inoculate the seed pieces with the bacteria and aid the development of the disease by destroying or preventing the formation of wound cork.

Cotton hopper.—In studies conducted at the Texas station it was found that the nymphs of the cotton hopper are capable of producing greater injury than the adults, and that nymphs obtained from horsemint cause more injury than those obtained from cotton. In control work dusts containing sulphur gave the best results, sulphur naphthalene giving better control than sulphur alone. An average of 92 per cent control was obtained with the immature stages, but the adults escaped injury by the dusts.

Thurberia bollworm.—A study of the life history and habits of the Thurberia bollworm, reported by the Arizona station, showed it to be closely restricted to the wild cotton and indicated that it will not become an enemy of cultivated cotton.

Thistle aphid on plum trees.—Nearly 100 per cent efficiency was obtained by the Idaho station against the thistle aphid on plum trees from the application of a spray composed of 0.5 per cent engine oil and nicotine sulphate at the rate of three-sixteenths pint per 100 gallons of water.

Aphid pests.—At the Texas station it was found that cold is no more of a factor than heat in producing winged forms of aphids, large numbers of winged forms having been produced in cages where the temperature rose to 110° F. The maturity of the cotton plants is apparently not a factor.

The mealy plum aphid was found by the California station in most instances not to winter in the egg stage

on prunes and plums but to migrate from tules and reed grasses to the orchards in the spring and back again in the fall. Soap sprays gave the best control of it.

The optimum temperature for the pea aphid, as observed by the Kansas station, seemed to be at or near 65° F. at a humidity of about 80 per cent, being most plentiful in the field during the months having an average temperature of 65°, namely, in April, May, September, and October. The indication is that the rainfall in March is a governing factor in respect to its damage to alfalfa in Kansas.

The melon aphid passes the winter, in Maine, in the egg stage, deposited on orpine, or live-forever, in September, according to the Maine station.

Insect pollinizers of fruit trees.—The New Jersey stations found honeybees and bumblebees to be the most important pollinizers in southern New Jersey. Honeybees were most advantageously distributed on fruit trees when the hives were placed singly 210 feet apart each way or about one hive to the acre. The lack of pollinizer was found most serious in apple and pear orchards situated in cultivated areas.

Buckeye poisoning of the honeybee.—The California station observed that wherever the California buckeye is abundant serious injury to bees occurs during years when a deficiency in topsoil moisture exists or when for any reason other plants fail to produce enough nectar to be more attractive.

European earwig.—The European earwig was found by the Oregon station to be controlled by a poison bran mixture consisting of sodium fluoride 12 ounces, molasses 2 quarts, wheat bran 12 pounds, and water 6 quarts.

White ants.—In the North Central States, white ants are becoming more and more destructive to public buildings and dwellings. The injection of kerosene into nests through holes drilled in the walls has been found by the Michigan station to give successful results, the efficiency of the kerosene being increased very materially by the addition of pyrethrum.

Onion thrips control.—Nicotine sulphate 1 to 1,500 with 3 to 4 pounds of a potash fish oil soap added to every 50 gallons was found by the Massachusetts station to give satisfactory control of the onion thrips.

Wax moth control.—Attention was called by the New Jersey stations to the fact that ethyl acetate with carbon tetrachloride, 30 pounds to 1,000 cubic feet, killed all larvae and pupae of the wax moth when exposed for 48 hours at a temperature of 60° to 85° F.

Protection of dairy cattle against flies.—In tests at the Indiana station of repellent sprays for flies attacking dairy cattle a new inexpensive spray composed of crank-case oil and oil of tar in proportions of 1 gallon to 1 pint gave the most promising results.

Insecticides.—The Tennessee station reported tests of a calcium fluosilicate compound which was found to be safe on foliage and effective as an insecticide when applied in heavy doses. It is not readily soluble, and is less toxic than sodium fluosilicate when used at the same rate. In tests of "light" and "extra light" forms of sodium fluosilicate, now obtainable in commercial quantities, the extra light form, containing about 70 per cent sodium fluosilicate, was found effective against some insects and safe on all foliage except tobacco. The fluosilicates were found especially effective against the striped cucumber beetle, blister beetle, and several flea beetles. In laboratory tests cutworms and grasshoppers readily succumbed to a bait composed of 20 parts of bran and 1 part of fluosilicate.

Investigating the possibilities and limitations of chloropicrin ("tear gas") as a fumigant for cereal products, the Minnesota station found that when flours or wheats treated with chloropicrin were exposed to the atmosphere for a sufficient time the chloropicrin disappeared from them. When chloropicrin was present in the flour deleterious effects were noted in the bread produced from such flour. Such effects appeared to be due to the ability of the chloropicrin to retard fermentation and to affect in a harmful manner the physical condition of the gluten-forming proteins. This station also reported the successful use of chloropicrin in combating the common insects found in flour and cereal mills. Diluted with an equal quantity by volume of carbon tetrachloride, it was best applied within the milling equipment by vaporizing the fumigant in the elevator heads while the mill was running. The great advantage of this fumigant is that it can be used within the machines and elevator legs without fire hazard and without serious personal danger. Small quantities of it can be used to destroy infestation in conveyors, bins, or pieces of idle equipment without interfering with the normal operation of the mill.

The preliminary experiments are said to indicate that frequent fumigation with chloropicrin will keep mill-infesting insects down to minimum numbers and greatly increase the intervals at which general fumigations are necessary.

From comparative tests of calcium cyanide and carbon disulphide the New Jersey stations were led to adopt the use of the latter in emulsion form for destruction of insects infesting market garden soil because of the lesser degree of injury caused by it to plant growth.

Homemade lubricating-oil emulsion containing 8 per cent oil was found by the New York State station to be an efficient ovicide, and, even if occasionally applied as an emergency measure when the buds are swelling, apparently causes no permanent ill effect to the tree. Arsenical sprays will control the roller but additional applications when the eggs commence to hatch are necessary.

ANIMAL PRODUCTION

BEEF CATTLE

Rate of growth.—The Missouri station observed that an animal severely underfed for practically all its life was still growing slightly at nine years of age. In body measurements this steer was nearly as large as other animals which had not been subjected to such severe underfeeding. The results indicated that weight alone is not a good index of growth in such animals. Underfed animals were generally able to fatten very rapidly when placed on ample rations.

Limited rations.—Rations limited to corn silage and cottonseed meal with and without cracked corn were found by the North Carolina station to be inadequate for reproduction in cattle, but when minerals, other proteins, and accessory food substances were added to the ration, practically normal reproduction and lactation followed, and the calves suckling such cows were able to make normal growth. Supplements of calcium carbonate, butterfat, cod-liver oil, yeast, steamed bone meal, and wheat embryo had a corrective effect on the cottonseed meal ration. In further studies four cows wintered on a ration of corn grain and corn fodder developed an unthrifty appearance, and calves were frequently born prematurely, blind, and weak; but healthy calves were produced and made normal growth when corn silage, steamed bone meal, and certain vitamin-carrying feeds were added to the ration.

Dressing and quality of beef.—Slaughter tests of heifer calves at the Nebraska station indicated that as the cattle were finished the dressing percentage increased and the percentage of water decreased, but there was little difference in the proportionate weight of the organs reduced to the net or empty body-weight basis. The percentage of internal fat, however, almost doubled, though very little difference was observed in the percentage of the various cuts which could be associated with the fattening of the animal. The percentage of the fat in the rib cuts increased during the fattening period, and both the percentage of lean and bone decreased.

Observations on Hereford, Shorthorn, Hereford-Brahman, and Shorthorn-Brahman steers, by the Texas station, showed that the dressing percentages increased as the finishing period advanced. Brahman cross-breds showed higher dressing percentages because of the smaller proportion of stomach and intestines and of stomach contents. There was also some indication that the Brahmans had less bone and less fat trimmings and more meat than the Herefords and Shorthorns. They also had lighter loins and ribs and heavier rounds and chucks. This station also found that the percentages of true fat in the lean and fat flesh of beef carcasses were almost perfectly correlated with the percentage of true fat in the entire animal. The percentage of offal fat to live weight was the most reliable single indicator of fatness. The percentage of fat in the lean of the wholesale rib cut was found to be the most accurate indicator of the degree of fatness of the entire animal of any single cut.

Supplementing range pasture.—Experiments at the New Mexico station indicated that when the range forage was more than sufficient for maintenance there were more or less regular and equal gains associated with each additional half pound of cake fed per head daily up to and including 1.5 pounds. Cattle receiving 2 pounds of cake per head daily made less gains than those receiving 1.5 pounds.

SHEEP

Fattening lambs.—In studies, at the Oregon station, of various methods of feeding a definite quantity of grain to fattening lambs, the lot fed at the

rate of 0.5 pound daily throughout the experiment made smaller gains than other lots receiving the entire 75 pounds of grain allowed per lamb equally divided over the last 100, 75, and 50 days, respectively, of the fattening period. The practice of lengthening the feeding period by giving the grain only during the final finishing period resulted in the consumption of a larger quantity of alfalfa hay and in finishing the lambs for market in April, when the price was usually highest.

Wintering ewes.—Ewes wintered on a full feed of alfalfa hay were in practically the same condition at the end as at the beginning, in an experiment at the Montana station, while the condition of others was considerably improved by feeding limited quantities of oats. Liberal hay feeding is recommended because of the better condition of the ewes so fed and their probable greater ability to withstand unfavorable conditions. In practically every case, in experiments at the Kentucky station, ewes receiving an ample amount of protein in the ration came through the winter in good condition and produced a larger lamb crop. Clover and alfalfa were the best sources of protein. The most satisfactory proportion of concentrates to roughage for wintering ewes at the Ohio station were 1 part of grain to 3 of roughage during pregnancy, 1 to 2 during lambing, and equal parts during the nursing period. In tests at the Oregon station of silage as a supplement to alfalfa hay for wintering ewes, it was found that 1 pound of silage was more efficient and less expensive than larger quantities and resulted in a saving of approximately 0.5 pound of hay. Silage also had some beneficial effect upon milk production.

Feeding screenings and weed seeds.—The North Dakota station found that pigeon-grass seed and wheat bran 4 to 1 fed with 1 pound of alfalfa hay produced fairly satisfactory gains in fattening lambs. A mixture of barley, pigeon-grass seed, and wheat bran, 2:2:1, produced as rapid gains as barley and bran alone. A mixture of barley, pigeon-grass seed, kinghead, and bran in nearly equal parts, fed unground, was found to be unpalatable and did little more than maintain the weight of the lambs. After grinding, however, satisfactory gains were made. Barley and wild oats, fed separately or mixed, produced similar gains, but 17 per cent more concentrates were required per unit of gain by the lots receiving wild oats than by the lot receiving barley. Wild oats and cultivated oats proved to be of practically equal value. Alfalfa screenings showed a distinct feeding value for fattening lambs in experiments at the Idaho station, 193 pounds of the screenings replacing 249.9 pounds of alfalfa hay and 144.5 pounds of barley.

Sheeping down corn.—Standing corn alone was found to be inadequate for fattening lambs at the Ohio and Illinois stations. In the Ohio experiments additions of linseed-oil cake and clover hay produced more satisfactory and economical gains, while rape seeded with the corn also proved to be a valuable supplement. In the Illinois experiments, supplementing the standing corn with limited quantities of alfalfa hay resulted in rapid daily gains which were almost equal to those made by lambs fed corn and legume hays in dry lots. Soy beans with corn also increased the rate of gain.

Mineral requirements.—The Ohio station found that the calcium balances of pregnant ewes were negative, i. e., they lost in calcium, on both timothy and alfalfa rations. Supplements of precipitated bone flour tended to increase the storage of calcium and phosphorus. All the animals in the experiments stored nitrogen, sulphur, potassium, sodium, magnesium, and phosphorus. The salt consumption of fattening lambs, in experiments at the Iowa station, varied with the kind of ration fed. Beet molasses tended to cause a very small salt consumption, whereas the largest daily consumption of salt was associated with a ration of corn and alfalfa hay. The substitution of corn silage, soy bean hay, or protein supplements for alfalfa decreased the salt consumption. Salt consumption was evidently increased as larger quantities of protein and fiber were consumed. Lambs consumed much more salt per unit of weight than steers.

SWINE

Screenings as feed.—The Minnesota station found ground flax screenings to be of value as a part of the ration of growing pigs, although pigs receiving barley in place of the screenings made more rapid gains and were better finished. The flax screenings consisted of approximately 25 per cent of pigeon-grass and lamb's-quarters seed and 2.84 per cent of immature flaxseed.

The screenings were high in ash, protein, fat, and crude fiber. The same station found cracked wheat produced by the usual process of cleaning wheat for milling to have a lower percentage of fiber and a higher percentage of protein and to produce more rapid gains when fed in combination with tankage than with barley, but the barley showed a greater tendency to fatten and finish the pigs.

Soft pork.—The more recent results of studies on soft pork conducted by the Alabama, Arkansas, Georgia, Indiana, Kentucky, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, and Texas agricultural experiment stations, in cooperation with the Department of Agriculture,[2] definitely showed that the soft pork problem was fundamentally one of fat metabolism, that soft pork contains a higher percentage of unsaturated fatty acids than hard fat, and that this is mainly due to the deposition of fats in the animal tissue which closely resemble those in the feed. On the other hand, animals fattened on feeds containing smaller amounts of fat synthesize hard fats from carbohydrates and proteins. The process of hardening on corn and nonsoftening supplements after previous softening was found to be essentially a dilution process, but pigs fed a softening feed for 60 days could not be hardened by feeding corn and tankage or corn and cottonseed meal during a subsequent period of like length, although the carcasses were hardened somewhat. Among the more common feeds found to produce soft carcasses were soy beans, peanuts, and rice polish, whereas brewers' rice and tankage tended to produce an extremely hard fat which was distinctly firmer than that of corn-fed hogs. A mixture of corn meal and peanut meal 5:1 was found to produce hard or medium-hard carcasses in pigs fed from 80 pounds to approximately 180 pounds during a feeding period of 9 to 10 weeks.

The carcasses of pigs receiving a ration of corn and alfalfa meal supplemented with tankage at the Illinois station were all hard, but the substitution of soy-bean-oil meal or the inclusion of soy-bean oil lowered the dressing percentage and produced relatively large numbers of soft carcasses. Soy beans alone proved to be an unsatisfactory ration for fattening swine at the Mississippi station. Soy beans were best used as a protein supplement to corn, sweet potatoes, and brewers' rice, in experiments at the South Carolina station, but a considerable percentage of the pigs fed a 2 per cent ration of corn with soy-bean or peanut forage, yielded soft or medium-soft carcasses, even after 84 days' hardening in dry lot on corn and tankage. Peanut-fed hogs is these tests showed more shrinkage during curing than corn-fed hogs.

Protein supplements.—A combination of equal parts of linseed meal and tankage proved superior to tankage as a supplement to corn for pigs on pasture at the Wisconsin, South Dakota, Illinois, and Nebraska stations. Corn-germ meal mixed with tankage was not as efficient a supplement as tankage alone or tankage and linseed meal. Fish meal and tankage as supplements to corn produced good gains, but linseed meal was inferior to both fish meal and tankage in experiments at the Florida station. In a test of various protein supplements to corn at the South Carolina station more rapid and economical gains accompanied the feeding of combinations of plant and animal proteins, soy-bean meal and fish meal proving particularly satisfactory. Substituting corn-oil-cake meal for three-fourths of the tankage in a corn and tankage ration reduced the daily gains and increased the cost of gain in an experiment at the Nebraska station. Supplementing a corn and tankage ration with alfalfa hay or alfalfa meal increased the rate of gains at the Nebraska, Illinois, and South Dakota stations. Fish meal proved somewhat superior to tankage and meat meal, respectively, as supplements to corn in tests at the Delaware and Florida stations, but cracked soy beans and soy-bean meal were not as good as tankage. The value of ground soy beans was considerably improved by supplementing with bone meal. Cottonseed meal, peanut meal, and soy-bean meal with minerals compared favorably with tankage as supplements to corn at the Arkansas station and produced more economical gains, but velvet-bean meal was unpalatable, as was linseed meal. Mineral supplements increased the efficiency of peanut meal and soy-bean meal, but did not improve rations containing cottonseed meal. The Ohio station found that soy-bean-oil meals made by the expeller and hydraulic

[2] HANKINS, O. G., and ELLIS, N. R. SOME RESULTS OF SOFT-PORK INVESTIGATIONS. U. S. Dept. Agr. Bul. 1407, 67 pp., illus. 1926.

processes were superior to solvent meal. The more desirable expeller process meal had a nutlike taste and odor. Favorable results from the use of whey, skim milk, and liquid and dried buttermilk as protein supplements were reported from the Mississippi, Florida, Illinois, and South Dakota stations.

Mineral and vitamin requirements.—Pigs fed for four months on a ration consisting of yellow corn, wheat middlings, and linseed meal without access to sunlight, at the New York Cornell station, developed a characteristic stiffness, which was rare in pigs exposed to sunlight. The ash content of the bones of the pigs exposed to the sunlight was markedly higher than that of the bones of pigs not so exposed. Supplementing the rations with bone meal and ground limestone increased the ash content of the bones and made them more nearly normal.

Experiments at the Ohio station indicated that a basal ration of white corn, wheat middlings, linseed meal, and salt was deficient in vitamins and in the quantity and quality of the minerals. Additions of ground limestone appeared to be more satisfactory than pure calcium carbonate in aiding normal bone formation, owing to the presence of impurities, including iron, in the limestone. Sunlight also acted as a stimulant to bone formation. Fractures were common in pigs fed cod-liver oil with the basal ration without calcium supplements, owing to the rapid stimulation of growth without proper skeletal development. Supplements of fish meal and tankage to the basal ration caused fairly rapid growth and good bone formation, but did not prevent the occurrence of stiffness. Posterior paralysis occuring in pigs on rations low in minerals and vitamins was found to be due to fractured vertebrae in the lumbar sacral region of the spinal column, resulting from poorly calcified bone. Rations of corn and vegetable proteins were found to be deficient in minerals. Pigs receiving salt as the only mineral supplement to corn and soy-bean-oil meal suffered greatly from stiffness. The addition of alfalfa meal and ground limestone caused some improvement, but the addition of bone meal to the ration gave the best results, both from the standpoint of the rate of gain and the health of the pigs. The Wisconsin station found that pigs fed rations of yellow or white corn with skim milk and minerals developed stiffness when not allowed access to sunlight.

POULTRY

Growth.—The Illinois station found that White Plymouth Rock cockerels grew at a distinctly more rapid rate than pullets, while the rate of growth of capons was similar to that of cockerels. Periodical variations in the growth rate were apparent, which were considered as related to environmental conditions and not cycles of growth. Body measurements and weights increased in approximately the same proportion with age, showing that the birds did not change materially in conformation during growth. There were no marked differences between the body measurements of capons and of cockerels of equal weights. The organs and parts of the carcasses increased in weight continuously with advancing age except that the digestive organs reached their maximum size before growth was completed. Pullets fattened more rapidly than cockerels, whereas capons occupied an intermediate position.

Rickets.—The exposure of chicks to direct sunlight or sunlight through Celo-glass prevented leg weakness and furnished sufficient antirachitic vitamin for normal growth, in an experiment at the Ohio station. A ration of white corn, wheat bran, tankage, and dried yeast supplemented with cod-liver oil, at the Illinois station, promoted nearly normal growth in practically complete darkness, but without cod-liver oil the ration was deficient in vitamins A and D. The Wisconsin station found it impossible to raise chicks to maturity on a ration of yellow corn and skim milk without access to sunlight. The Kansas station found that sufficient antirachitic vitamin for normal growth of chicks on a grain and tankage (9:1) ration was supplied by 0.5 per cent of cod-liver oil, five minutes' daily exposure to ultra-violet light, or daily exposure to the sunlight, but supplements of 2 per cent irradiated cottonseed oil, 10 per cent green alfalfa, or sprouted oats did not prevent rickets.

Supplementing the ration of the birds in the Michigan egg-laying contest with green feed and condensed buttermilk to which 6 per cent of cod-liver oil was added not only controlled leg weakness but considerably increased winter egg production. The

quality of the eggshells was improved and the percentage of blood spots decreased.

Egg production and hatchability.—The Ohio station found that cod-liver oil and added minerals increased egg production, while ultra-violet light increased both egg production and the hatchability of the eggs. Alfalfa and clover hay proved superior to cabbage for egg production and for hatchability and lessened mortality. The Wisconsin station came to similar conclusions.

Ultra-violet light and cod-liver oil increased the egg production of birds fed from hatching on a basal ration of mixed grains, minerals, and skim milk, but without access to direct sunlight, in experiments at the Wisconsin station. The percentages of eggs which were fertile and which hatched were considerably increased by the ultra-violet light treatment. Chicks from the eggs of nonirradiated birds contained only about one-half as much total calcium at hatching as chicks from irradiated hens. The yolks of the eggs from the irradiated birds were practically 10 times as potent in vitamin D as were those from the nonirradiated birds. Direct exposure of the eggs from the nonirradiated pens to ultra-violet light for from 1 to 40 minutes had no effect on the hatchability, indicating that such irradiation did not penetrate the shell.

Protein feeds.—The stations which have tested the comparative efficiency of high-protein feeds have generally found that the animal proteins are only slightly superior to vegetable proteins when the latter are properly supplemented with minerals. Liquid skim milk and buttermilk and semisolid and dried buttermilk have generally proved slightly superior to other sources of animal proteins. Fowls fed cottonseed meal to the extent of 38 per cent in the mash with alfalfa range, at the New Mexico station, produced very small eggs with black spots covering from one-third to two-thirds of the yolks, which made the eggs unmarketable. The spot was not evident in the eggs of birds, in a yard devoid of green feeds, receiving the same quantity of cottonseed meal, or in those of birds on range having 15 per cent of cottonseed meal in the mash.

Mineral supplements.—The Ohio station, comparing various sources of calcium as mineral supplements, found that the best growth was obtained with tricalcium and dicalcium phosphate, raw bone meal, spent bone black, or bone ash. Calcium supplements were found by the Kentucky station to increase the weight of the egg and of chicks hatched from the eggs. A lack of calcium in the ration caused a large reduction in the number of eggs laid by confined birds, but not in case of birds having free range.

Grit was found to be unnecessary in the diet of growing chicks by the Kentucky and Ohio stations. The natural craving for grit by fowls is attributed by the Ohio station to the chickens' desire for the minerals which the grit supplies.

Salt in the mash.—Use of as much as 8 per cent of salt in the mash apparently had no detrimental effect on chickens, in experiments at the Illinois station, though those receiving 8 per cent made slower and less economical gains than those receiving 1, 2, or 4 per cent. Doses of from 6 to 10 grams were quickly fatal while from 4 to 6 gram doses were required to produce death.

Scratch feed.—The Illinois station found that pullets receiving all their grain in boxes night and morning laid just as well as those fed in the litter, thus tending to disprove the contention that it is necessary for laying hens to receive scratch feed in the litter in order that they may obtain necessary exercise.

Egg laying cycle.—The results of studies at the Massachusetts station indicated that the length of the winter laying cycle is subject to various environmental influences, but is also correlated with the winter and annual egg production. Reduced winter production, due to increases in the length of the winter pause, was partially compensated for by subsequent increases in production. Early maturing birds were found by the Missouri, California, New Jersey, and Idaho stations to make the largest annual and winter egg-production records. The Kansas station found no correlation between the date of hatching and the age of laying the first egg, but birds starting to lay young never laid as large eggs as those starting to lay when more mature. The Idaho station arrived at a similar conclusion.

Incubation.—The Illinois station found that turning eggs during the first six days gave as good results as turning during the entire incubation period, while turning from the thirteenth to the eighteenth day gave no better results than no turning. Preliminary observations, at the Massachusetts station, on chick embryos dying after the eighteenth day of incubation showed that a large percentage of

such embryos were in abnormal positions, due possibly to the handling and turning of the eggs. No injury resulted from storage of fertile eggs for 5, 10, 12, and 15 days at 32° F. in experiments at the Missouri station, but 45 days' storage at this temperature prevented development, as did 25 days at from 28° to 32°, or 4 days at 0°.

Flavor in poultry meat.—When a ration containing 4 per cent of cod-liver oil was fed for two or more weeks at the Indiana station, an unusual taste was observed in the chicken meat, even after 10 days' discontinuance of the cod-liver oil. Such flavor was least noticeable in fried chicken and most noticeable when the meat became cold.

DAIRYING

Numerous investigations dealing with the relation of environment and the physiological condition of the animal to the secretion of milk and its constituents have been conducted by the experiment stations.

Temperature and season.—The Georgia station found that artificially cooling dairy cows by covering them during the day with light muslin cloths kept moist overcame the depressing effects of hot weather. Cows so cooled showed better appetites, better food assimilation, and produced larger amounts of milk. The Missouri station found that between 70° and 30° F. the fat percentage of the milk increased approximately 0.2 per cent for each 10° reduction in temperature. The Illinois station found that a falling temperature from day to day increased the percentage of total solids in the milk and that the solids content decreased with a rising temperature, though no noticeable difference was observed in the yield of milk. The results indicated that a cool, moist climate is best adapted for maximum milk production.

Milk secretion.—The Missouri station found that the monthly milk and fat production of nonpregnant cows declined as a constant percentage of the preceding month's production after the maximum was reached. As an index for expressing the persistency of milk and fat secretion the ratio between the total production and the highest month's production was found to be very satisfactory. The persistency of lactation was closely related to the initial rate of production in Guernsey and Holstein cattle. The higher the initial rate of production the more rapid the rate of decrease in yield with advance in lactation. Persistency was not affected by age, except as age affected initial production. Initial yield was a more powerful factor affecting yearly yield than persistency. The Illinois station found that milk production declined more rapdly in cows after five months of pregnancy than in farrow cows.

Heat tended to cause a reduction in the quantity of milk produced by dairy cows at the Iowa station. The daily production before and after breeding was nearly always heavier than the production of the day of breeding, even for the different breeds. The highest average production occurred at two days before breeding.

Influence of feed on fat percentage.—The percentage of fat in the milk was materially increased by feeding large quantities of oil, either in the whole seed or as oil extracted from sunflower seed, soy-bean seed, high-oil-content corn, flaxseed, and peanuts in experiments at the Illinois station.

Protein and energy requirements.—Experiments at the Pennsylvania Institute of Animal Nutrition with cows in varying stages of lactation indicated that the relative utilization of the net energy of the feed for the respective purposes of maintenance, body increase, and milk production was in the proportion of 1 : 0.761 : 0.985, showing that feed was more efficiently used for maintenance and milk production than for body increase. The maintenance requirement for digestible crude protein for fasting cows was 0.6 pound per 1,000 pounds live weight. The Ohio station found that cows receiving considerably less protein with an excess of digestible nutrients over that prescribed by the Haecker's standard maintained their live weight and milk production during entire lactation periods and reproduction was normal.

Concentrates.—The Kansas station found that kafir was 97.6 per cent as efficient for milk production and 95.8 per cent as efficient for fat production as corn. Both were equally palatable. When rice meal replaced corn in a grain mixture with bran, linseed oil meal, gluten feed, and cottonseed meal fed with alfalfa hay and corn silage, the Arkansas station found that more milk and butterfat were produced accompanied by larger gains in live weight, and less feed was required to produce a unit amount of milk and fat.

Hay.—The importance of legume hays has been emphasized by the work of the experiment stations. Dairy heifers made almost identical gains during 18 weeks in experiments at the Arkansas station when fed alfalfa or cowpea hay with silage and grain, though more grain was required per unit of gain on the cowpea-hay ration, and better development and growth were observed with alfalfa. Soy-bean hay and alfalfa hay of similar quality proved to be of practically equal value for dairy cattle in experiments at the West Virginia, Pennsylvania, Ohio, Wisconsin, and Mississippi stations, but there was generally more wastage of the coarse stems of the soy beans. In the experiments at the Mississippi station soy-bean hay and alfalfa hay proved superior to Lespedeza hay for milk and fat production, but cows lost weight on the soy beans. In an experiment at the Maryland station soy-bean hay proved inferior to wheat bran and mixed hay for milk production, but the calculated feed cost per pound of milk and butterfat was less on the soy-bean ration. Chaffing and grinding of soy-bean hay was found by the Illinois station to increase its digestibility. Grinding alfalfa hay was found by the Michigan station slightly to improve its value for milk production, but the difference was so small that grinding appeared neither necessary nor profitable.

In a comparison of native hay with alfalfa hay for milk production the Wyoming station found that no combination of hay and protein concentrates was equivalent to the standard ration of alfalfa, silage, cereal grains, and a small quantity of cottonseed cake. The main faults of the native hay appeared to be its lack of palatability and protein. A combination of alfalfa and native hay was not quite equivalent to the alfalfa hay. Wheat hay fed as the exclusive ration for dairy heifers was found by the California station to produce larger gains in body weight per pound of feed than barley, oat, or rye hays. The main difficulty with rye hay was its lack of palatability.

Calf rations.—Calves made growth to 5 months of age comparable with Eckle's standards in experiments at the Arizona station when whole milk was gradually replaced after 10 days of age by a gruel consisting of corn meal, wheat middlings, oat flour, linseed oil meal, blood meal, ground bone meal, and salt, with complete replacement of the milk at 40 days of age. Another group of calves, however, receiving the full ration of whole milk until 30 days of age, with a gradual replacement by the home-mixed gruel after this period, was considerably heavier when 5 months old. A calf meal consisting of ground rolled oats, skim milk powder, linseed meal, cornstarch, corn sugar, alfalfa flour, calcium chloride, and salt gave good results as a substitute for part of the whole milk and skim milk ordinarily fed to calves in experiments at the Massachusetts station. Skim milk powder appeared to be a most promising ingredient of calf meals.

Vitamin requirements of calves.—The Pennsylvania station found that calves have a very low vitamin B requirement, but they are evidently able to synthesize this substance by the action of the bacterial flora of the digestive tract or by other means. The vitamin B deficient ration produced strong healthy calves up to 540 days, but was inadequate for lactation. However, the milk produced on the deficient ration was as rich in vitamin B as that from cows fed on the usual winter rations of silage, grain, and legume hay.

Vitamins in milk.—Tests at the Nebraska station indicated that Jersey milk is richer in vitamin A than Holstein milk, and that Guernsey milk is richer than Ayrshire milk, probably due to the higher fat content of Jersey and Guernsey milk. It was also found that milk produced under summer conditions had a higher value for growth promotion than milk produced under winter conditions.

Mineral nutrition.—The Wisconsin station found a very definite relation between calcium assimilation and sunlight. Summer sunlight was relatively weak in its antirachitic properties as compared with radiations from a quartz mercury vapor lamp. Positive calcium balances were established in milk goats by 10 to 20 minutes' daily exposure to ultra-violet light. Clover hay was distinctly more favorable to calcium assimilation than timothy hay in experiments at the New York Cornell station. The calcium and phosphorus contents of the milk were relatively constant on the clover and timothy rations. The Oregon station found that no minerals except chlorine were lost from the body during gestation. Additions of kale and bone meal proved favorable to mineral assimilation.

Market milk tests.—Tests of the reliability of the methylene blue reductase test as an indicator of the keeping quality and grade of market milk by the New York Cornell station showed an 86 per cent agreement with the microscopic count. The Pennsylvania station found that the methylene blue test correlated very closely with the bacterial count in grading patrons' milk at the station creamery, but that it could not replace the plate count for the discrimination of milk containing small numbers of bacteria. The New Hampshire station found that the reductase test served as a simple and inexpensive method of determining the keeping quality of milk. The initial acidity of the milk was found to be an inaccurate indicator of the keeping quality. The Michigan station found, however, that the pH score of milk samples checked very closely with the keeping quality of such samples.

Creaming of milk.—The West Virginia station found that raw milk consistently had a deeper cream layer and a more definite cream line than Pasteurized milk, but Pasteurization at 145° F. for 30 minutes followed by cooling without pumping had little effect upon the creaming. Pumping the milk at 145° reduced the cream layer 6 per cent. The amount of reduction was consistently reduced as the temperature at which the cream was held when pumped was lowered. On the other hand, the Pennsylvania station found that the temperature of Pasteurization did not appear to affect the creaming ability unless it was higher than 212°. Additions of solids-not-fat in the form of plain condensed skim milk or skim milk powder did not increase the creaming ability, though clarification of raw milk decreased creaming and clarification of hot milk intensified the effect. Milk held at a low temperature for several hours and clarified at 85° showed an increase in creaming ability. Mixing fresh raw cream and skim milk had only a slight but variable effect on the amount of cream rising, but the mixing of Pasteurized skim milk with raw cream produced a considerable loss in the cream layer. Homogenization of whole milk reduced the volume of cream at all pressures, but when the cream only was homogenized an enormous increase in the cream volume was observed.

The size of fat globules did not affect the creaming qualities of milk in studies at the Minnesota station, but there was a relation between the solids-not-fat and viscosity, which, however, was found to be only a minor factor in influencing creaming. The reduction in the creaming power of Pasteurized milk was due to the fact that more fat was left in the lower layers of the milk and to closer packing of the fat globules in the cream layer.

Buttermilk.—In a study of the effect of storing buttermilk in metallic tanks, the Oklahoma station found that tin and aluminum strips suspended in buttermilk had no noticeable effect on the flavor, while distinct metallic flavors were apparent when strips of copper or zinc were so suspended. Copper and zinc had no influence on the tendency of buttermilk to whey off; but there was some indication that the curd formed was firmer in a controlled sample than in buttermilk in which copper and zinc were suspended. The best sterilization of skim milk for use in the manufacture of commercial buttermilk occurred when it was heated to a temperature of from 180° to 190° F., and immediately cooled, and the best flavor resulted when the acidity was allowed to develop to from 0.8 to 0.85 per cent. Wheying off did not occur as frequently if the curd was broken without undue agitation, and was then rapidly cooled to 45°. The addition of salt to buttermilk up to 0.5 per cent had no effect on the wheying-off tendency and no particular advantage was found for such addition. A distinctly undesirable flavor was produced with too large quantities of salt.

Clarification.—Studies by the Idaho station indicated that temperature did not affect the amount of visible dirt removed, the flavor and keeping quality of the milk, or the cream line, though milk clarified at low temperatures gave smaller increases in bacterial counts.

Pasteurization.—Considerable of the controversy over the inefficiency of Pasteurization of milk in the destruction of living organisms has generally been due to inaccurate Pasteurization equipment or improper control of the length of the Pasteurization period or the temperature used. Milk, Pasteurized in commercial equipment in which defects such as leaky valves, dead pockets, etc., were eliminated, was made free from harmful living tuberculosis bacteria at temperatures of 142° F. for 30 minutes in experiments at the Illinois station.

Cleansing dairy utensils.—Rinsing milk bottles, churns, and dairy utensils or allowing the tubes of a milking machine to stand in chlorine solutions was found by the Minnesota, Michigan, and Illinois stations to reduce the numbers of living bacteria present materially. The keeping quality of the cream was considerably improved at the South Dakota station when the separators were thoroughly washed and scalded and the bacterial content was materially reduced.

Starters.—The Iowa station found the best starters were produced when the air supply was moderately limited. When the air supply was too greatly restricted acid development was rapid but the flavor was not so good. With an unrestricted air supply the flavor was good, but the acid and aroma were poor. Incubation temperatures of 18, 21, and 25° C. gave good results. Those coagulating in from six to eight hours were superior to those requiring a longer time for ripening. Considerable variation was found in the acidity produced by a given starter in samples of milk of different origin. Milk high in total solids produced a relatively high acid content in the starter, owing to the fact that high total solids indicated a high initial acidity and a high ash and fat content. Off-flavors in an original sample of milk usually tended to produce a poor-quality starter. Additions of fat or water to milk used for starter purposes reduced the development of acidity and materially lowered the score. Additions of lactose had somewhat the same effect, whereas additions of milk ash had no effect on acidity and only a slight effect on flavor.

Keeping quality of butter.—Sour cream Pasteurized at 170° F. by the holding process was found by the Iowa station to produce a better quality of butter than cream Pasteurized at 140°, but the keeping quality of the butter was reduced by the higher Pasteurization temperature. Butter made from cream Pasteurized at 180° had an overheated flavor. Neutralization of sour cream improved the quality of butter for storage. The Illinois station found that butter crushed in its passage through certain printing machines did not keep as well as butter not so treated, but developed undesirable flavors. Pasteurization was found by the Minnesota station to enhance the keeping quality of butter by the elimination of substances causing deterioration other than peroxidase. The addition of peroxidase to sweet and ripened Pasteurized cream indicated that this substance had no effect on the composition of the butter made from the cream, even after storage for 11 months at room temperature and at 0° C. Farm butter stored in a saturated solution of salt scored higher in tests at the North Dakota station than that stored in small stone jars or in self-sealer glass fruit jars.

Cheese.—The Idaho station found that cheese manufactured from Pasteurized milk scored higher than cheese from un-Pasteurized milk. Differences in the starters were also found to distinctly affect the flavor of the cheese produced. The Illinois station was able to produce a satisfactory cottage cheese from Pasteurized skim milk, using a pure lactic acid culture with or without the addition of rennet or pepsin. Washing the curd before salting removed much of the lactic acid and consequently much of the flavor. Cheese from washed curd was found to spoil more rapidly.

Comparing pure cultures of various organisms with standard starters of mixed cultures in relation to the production of flavor in Cheddar cheese, the New York State station found that *Streptococcus paracitrovorus* was slow in the development of acid, but cheese made with it was better broken down and a more pronounced flavor was apparent after three months than in cheese made from milk inoculated with a standard starter. *S. citrovorus* appeared to have no influence on the production of flavor. *S. lactis* produced cheese varying considerably in quality according to the strain used, but in general the flavor was inferior to that of cheese produced with a standard starter. When lactic acid was added to milk in quantities equivalent to that produced by a starter the quality of the resulting cheese was similar in both cases. Freezing of milk did not appear to have any effect on the quality of Cheddar cheese produced from it, while Pasteurization of such milk improved the score of the resulting cheese. This improvement was particularly pronounced in milk containing relatively small numbers of bacteria.

Viscosity of ice cream.—The viscosity of ice cream was found by the California station to be most influenced by gelatin, though it increased during aging and slightly with additions of sugar. Fat did not appear to increase viscosity to any great extent, and se-

vere agitation during Pasteurization and freezing reduced it materially. Viscosity was increased by the use of improvers containing coagulating enzymes or gums in experiments at the Oklahoma station. The Iowa station found that viscosity and the size of the clumps of the fat globules in ice cream decreased as the amount of agitation during freezing increased. Stirring the ingredients of the mix also decreased the viscosity of the product materially.

Emulsification, viscolization, and homogenization increased the viscosity of the ice cream mix at the Missouri station, but a further increase occurred when the mix was reemulsified two or three times, though viscolizing and homogenizing a second or third time decreased the viscosity. The bacterial content was increased each successive time the product was processed, but the body and the texture of the resulting ice cream was improved. The maximum dispersion of the butterfat into the serum seemed to be more important than viscosity in determining quality.

Shrinkage of ice cream.—The Connecticut Storrs station found that as the overrun increased from 80 to 100 per cent the shrinkage at the time of dipping into quart containers increased from 26 per cent to 49 per cent. The shrinkage was likewise greater with higher storage temperatures, irrespective of the overrun. The use of certain types of ice cream improvers was found by the Illinois and Oklahoma stations to be a possible cause of shrinkage after ice cream was several days old. Certain commercial improvers caused an enzymatic change in the milk protein which favored shrinkage. Alterations in the temperature, long storage periods, high overrun, high acidity in the mix, high percentages of solids-not-fat, and increases in the concentration of these solids in the water of the mix tended to increase the shrinkage of ice cream containing certain improvers.

Nonhomogenized ice cream mixes gave the lowest overrun in experiments at the Pennsylvania station, while the largest overrun was obtained when the entire mix was homogenized, though greater overruns occurred when the homogenization pressure was 2,500 pounds than when it was 4,000 pounds. The melting resistance was greatest with the highest homogenization pressure. The use of one valve on the homogenizer increased the viscosity. Too high pressures in homogenization produced mixes which were very thick and viscous and required a long time to freeze, but when low pressures were used the resulting ice cream was coarse.

Ingredients, freezing point, and quality of ice cream.—The Indiana station found that increases in the fat content of mixes from 8 to 17 per cent, aging up to four weeks, and increases in the quantity of gelatin from 0.5 to 4 per cent, had no effect on the freezing point. Increases in casein from 5.6 to 15 per cent lowered the freezing point 0.8° C. The freezing point was also lowered 1.6° by increasing the sucrose content from 12 to 19.2 per cent. Increasing the lactose content from 6.2 to 15.6 per cent resulted in lowering the freezing point 1.2°, while the development of lactic acid from 2.3 to 8.5 per cent resulted in a reduction of the temperature of freezing 0.6°. Partial neutralization of lactic acid with sodium bicarbonate also slightly lowered the freezing point. Water-soluble substances, such as serum solids, sugar, and various flavors, lowered the freezing point of the ice cream mix and increased the time required for freezing in tests at the Pennsylvania station. Overrun was obtained more quickly with brine at lower temperatures. One of the most important factors influencing overrun was the temperature of the mix when the brine was shut off. Aging from 4 to 24 hours did not affect the time required to produce a 100 per cent overrun, though aging improved the texture of the finished product. Mixes containing corn sugar were found by the Kansas station to freeze at a slower rate than mixes containing cane or beet sugar, the increase in the freezing time being in direct proportion to the quantity of corn sugar present. Overrun was also obtained with more difficulty when this product was used. The flavor, body, and texture of ice cream, however, made with corn sugar was satisfactory except when more than 30 per cent of the cane sugar was replaced by corn sugar.

DISEASES OF ANIMALS

Infectious abortion.—Progress in the investigation of infectious abortion was reported by a number of the stations. Results reported by the Connecticut Storrs station, contrary to those obtained in earlier work, support the conclusion of other stations that infection of cattle by the abortion

organism may take place through the mouth. The Missouri station found that bulls are not readily infected with *Bacterium abortum* by way of the mouth or the urethra.

The essential measures of control of infectious abortion of cattle, as indicated by the work of the Michigan station, are the mating of animals having healthy reproductive organs, an environment for pregnant cattle that minimizes the danger of infection subsequent to conception, and a system of herd management that assures the maintenance of the herd on a high plane of health in order that resistance to infections may be high. The Missouri station, cooperating with other stations, found the serological tests for infectious abortion to be exceedingly accurate and practical in the diagnosis of the disease.

The results of use of a bacterin in antiabortion vaccination experiments at the Arkansas station, while not conclusive, were sufficiently encouraging to make a continuation of the tests desirable. Some degree of immunity induced by the use of the living vaccine was observed by the Minnesota station, but the abortion rate was not reduced to a desirable minimum and it was concluded that the vaccine should never be used in other than badly infected herds.

By a system of handling and sanitation practiced at the Kentucky station, the percentage of foals in a number of studs was increased from 50 and 60 per cent to 75 and 80 per cent.

Infection of the herd of swine with *B. abortum* was found by the Missouri station to be dying out due to a diminished virulence and infectiveness of the strain of *B. abortum*. Some carriers of the organism conceived and farrowed average or even large litters of living thrifty pigs, but a large number of such carriers did not prove profitable because of their small litters and the loss of pigs. Experiments with swine at the Illinois station suggest that naturally infected females may harbor the virus of the disease in the reproductive organs for an indefinite period, thus differing from cows, in which the virus is eliminated from the uterus in from six to eight weeks following abortion.

Bacillary white diarrhea.—This disease continued to engage the attention of investigators in a number of the stations, the work being aimed particularly at elimination of infected fowls and control of the disease.

At the Kansas station it was found that bacillary white diarrhea was disseminated by artificially infected chick down placed in a forced-draft air-tight type of incubator.

In work with the agglutination test for bacillary white diarrhea the Indiana station found that 2 cubic centimeters of a 2 per cent water solution of sodium hydroxide added to 100 cubic centimeters of *Bacterium sanguinarium* antigen did not influence its agglutinability and eliminated 95 per cent of the cloudy tests when added just before setting up the test.

The causative organism of bacillary white diarrhea and that of fowl typhoid are, according to the Rhode Island station, so similar in their characteristics, particularly in gas formation on sugar media, that they should be placed in the same genus. The Michigan station found that *Bacterium pullorum* varies in many characteristics, particularly in physiological properties, and that the variations are not constant. The agglutinability of strains of the organism was also found to vary.

That the so-called cloudy reactions occurring in the agglutination test for bacillary white diarrhea are due to excess protein in the blood of hens or pullets, more especially those laying heavily, was the conclusion of the Michigan station. Heavy-producing flocks gave the highest percentage of cloudy reactions, no matter what the composition of the ration had been. Flocks of low productive ability showed few or no cloudy reactions even when well fed. No cloudy reactions were obtained from males, and comparatively few were encountered during the time of molting. A bacteriophage active against the causative organism of the disease was obtained from chicken feces.

A system of management of poultry by which bacillary white diarrhea can be prevented or controlled was described by the Maryland station. Its several steps are (1) prevention of spread by darkening the nursery compartment of the incubator until the chicks are 48 hours old, (2) removal from brooder and destruction during the first few weeks of all unthrifty chicks, (3) removal from range flock of all fowls that have escaped rigorous culling, and (4) selection of the best layers (matured) for the breeding pen. In comparative tests at the Rhode Island station a hypochlorite solution with about 0.02 per cent of available

chlorine, used in the drinking water, was the only substance that appeared to have any effect, the mortality of the lots so treated being about one-third that of the control lots and the lots given other chemicals.

Fowl typhoid.—At the New Jersey stations the organism of fowl typhoid was isolated from the heart blood of young chicks on several occasions, from the unabsorbed yolk of young chicks, and from the ovary of an adult hen, thus indicating that the infection is quite common in young stock and indicating the possibility that the chick may be affected through the egg, as occurs with bacillary white diarrhea.

The fowl-typhoid organism was found by the California station to be an important cause of disease of chicks as well as of adult fowls. Evidence was obtained indicating that adult hens may acquire chronic infection of the ovaries with the fowl-typhoid organism and transmit the infection through the egg.

Avian tuberculosis in cattle and swine.—In continuation of earlier work, the Wyoming station found that avian tubercle bacilli tend to remain localized when they gain entrance through the skin to the subcutaneous tissues of calves, even when introduced in large numbers. That avian tuberculosis is being perpetuated in swine independent of continuous direct exposure to infected fowls and that such infection may be transmitted from pig to pig is considered probable by the Illinois station.

Hog cholera.—The Indiana station found that hog-cholera virus can be transmitted across small spaces regardless of ordinary pen partitions and without direct contact and that such transmission can be prevented by placing a cheesecloth curtain between the pens. The virus remained alive for varying periods in mixtures of soil and blood, urine, and feces of diseased animals, and of straw bedding and infected blood. Feces-soil and urine-soil mixtures were not virulent 24 hours after removal from the bodies of cholera hogs. Dry straw bedding on which blood had been sprinkled five days previously infected exposed pigs.

Anthrax.—The Arkansas station succeeded in producing immunity to anthrax in rabbits and sheep by use of a culture attenuated by growth for six weeks upon a standard agar culture plus 4.5 per cent sodium chloride at a temperature of 37° C. A single injection was found to protect sheep against subsequent infection with a virulent culture. The immunity conferred by the vaccine was general.

Swellhead of sheep and goats.—Investigations by the Texas station indicate that this disease has a direct relation to deficiencies in the food of the animals.

Internal parasites.—So-called salmon poisoning in dogs and foxes was found by the Oregon station to be caused by a small intestinal fluke, a new species, a cystic form of which occurs in the muscles and other organs of trout and fresh-water salmon. Dogs that recover are immune and can eat parasitized fish with impunity.

The Michigan station found that various aqueous solutions of "hyperactive" iodine containing 0.05 per cent iodine may be successfully employed to rid dogs and foxes of internal parasites. Administered per rectum under pressure, both hookworms and roundworms appeared to be completely destroyed. This iodine solution was also successfully administered as an enema in several human cases of mucous colitis and amebic dysentery.

Coccidiosis in chicks.—The Ohio station found that with chicks kept on floors of 1-inch poultry netting elevated so that the droppings passed beyond reach of the chicks the death rate from coccidiosis was greatly reduced as compared with that in chicks kept on cement floors. The Texas station found that the feeding of buttermilk to chicks materially decreased the mortality from this disease.

Poultry lice and mites.—The use of sodium fluosilicate was found by the Tennessee station to be superior to sodium fluoride for freeing fowls of lice. A dust bath made of 3 parts finely ground phosphate rock and 1 part sodium fluosilicate was found to be a very simple method of freeing the farm flock from lice.

Poisonous plants.—Studies at the Nevada station showed the common choke cherry to be poisonous to sheep and cattle. The leaves contain hydrocyanic acid and are poisonous from the end of April to the first of October.

Chemical examinations made at the Wyoming station of three delphiniums, showed two, *Delphinium bicolor*, a low-growing species, and *D. cuculatum*, a tall species, to be responsible for cattle losses, but *D. nelsonii*, a widely distributed, low form, appears to be harmless under range conditions. The silvery lupine was found by this sta-

tion to be poisonous to sheep, and range studies showed that other lupines as well play an important part in sheep poisoning. The North Dakota station found that molded, spoiled, or damaged sweet clover hay and silage caused a definite hemorrhagic disease in cattle, manifested by swellings under the skin and a stiff, lame gait, although either or both of such symptoms may be absent.

FOODS AND HUMAN NUTRITION

Wheat flour and bread.—The Nebraska station, in an investigation of the value of the viscosity test as a measure of the baking quality of Nebraska wheat flours, found a low positive correlation between loaf volume and protein content and between actual viscosity and loaf volume, a still lower positive correlation between loaf volume and actual viscosity after removal of electrolytes, little or no correlation between loaf volume and ratio of actual viscosity to protein content, and a high positive correlation between actual viscosity and protein content. These results are thought to indicate that, at least for the particular series of 100 flours tested, the protein content is a more valuable criterion than actual viscosity for predicting flour strength.

The organic acids accumulating in cracker sponges and bread dough during fermentation were found by the Montana station to consist chiefly of lactic acid, with a small amount of acetic acid. Lactic acid constituted from 78 to 95 per cent of the total organic acids in the cracker sponge and 75 per cent in the bread dough.

A mechanical dough mixer has been invented at the Kansas station which by a combined pack-squeeze-pull-tear mechanism is said to produce a dough capable of making a light bread with only panary fermentation.

Recipes for making a satisfactory bread from soft wheat flour with dry yeast have been developed by the home economics department at the Missouri station. The best results were obtained by using scalded flour or potato for a preliminary fermentation and potato water, milk, or buttermilk as the liquid.

Corn for hominy.—In a comparison at the Iowa station of 12 varieties of corn for hominy purposes, the varieties having broad kernels gave the best results, the three ranking highest being Hickory King, White Elephant, and Commercial White. The hominy from yellow corn and flint corn was unattractive in appearance but of good flavor. Sweet corn gave a soft gummy unsatisfactory product. With a given variety the best hominy was obtained when the corn had a moisture content of from 10 to 15 per cent and the lye solution a concentration of 2 per cent. Bleaching was found essential to prevent blackening in the can. Incipient boiling rather than holding at 70° C., and mechanical agitation during boiling are recommended as hastening the process.

Relative economy of various cuts of beef.—The Missouri station has made a comparative study of the physical composition of lean, half-fat, and fat beef carcasses of about the same weight and has calculated the relative economy of the various cuts. The dressing percentages varied directly with the condition of the steers, but the percentages of the different cuts showed only slight variations. The lean meat of the half-fat steer had the highest percentage of protein, the thin steer of water, and the fat steer of fat. In every cut of the fatter animal the cost of a given amount of protein was higher and of 1,000 calories lower than that of the thin. The various cuts in order of increasing cost of protein were chuck, round, rib, and loin. As a source of lean meat porterhouse steak was the most expensive cut of the fat carcass and club steak of the lean. The least expensive cuts were clod and plate, respectively. As a source of total boneless meat the chuck was the least expensive, followed by flank, round, sirloin, club, and porterhouse.

Salting of meats.—In experiments at the Kansas station, 8 pounds of salt per 100 pounds of meat proved to be the most satisfactory quantity to use for curing ham and bacon. The shrinkage during smoking and storing was little, if any, affected by the salt. Smoked salt was fairly satisfactory when material for smoking and smokehouses were not available, but the cured meat was inferior in color, though the shrinkage was less and the bacons held their shape better. Dry curing with smoked salt was inferior to brine curing with smoked salt.

Vinegar making.—An investigation at the Washington station of the reasons for frequent failures to secure proper vinegar fermentation under average farm conditions has led to the publication of definite recommendations

which, if closely followed, are thought to insure the production of cider vinegar of uniformly excellent quality under conditions prevailing in that State. Inoculation with pure cultures of both yeast and vinegar bacteria were found to hasten the process, particularly at the lower temperatures prevailing in unheated farm cellars. Fermentation was much more rapid at a higher temperature. Vinegar of marketable strength was obtained in many cases in less than four months at a temperature of from 65° to 75° F., as compared with nearly a year at 45° to 55°. It is considered best not to add the vinegar bacteria until after the completion of the alcoholic fermentation and not to remove the sediment until after both fermentations have been completed, when the vinegar should be transferred immediately to clean containers and bottles. It is emphasized that the barrels and all utensils used for vinegar making should be thoroughly scalded with steam or boiling water and rinsed with plenty of clean water and that the apples should be sorted and washed before pressing.

A method has been developed by the Michigan station for the home manufacture of vinegar from surplus honey. An essential feature of the method is the proper dilution of the honey, with the addition of suitable salts for the growth of the alcoholic and vinegar bacteria with which the solution is inoculated from suitable starters. At the Illinois station it was found that the addition to the cider of yeast food in the form of small amounts of ammonium acid phosphate (0.08 per cent) and ammonium acetate (0.02 per cent) shortened considerably the time required for both alcoholic and acetic fermentation. The use of water valves to exclude air during the alcoholic fermentation and thus prevent acetic acid fermentation was without advantage. The rate of acetic acid fermentation was much more rapid in kegs half full than nearly full.

Manufacture of table sirup.—Various methods of clarifying cane juice for the preparation of table sirup have been developed and tested at the Louisiana station. One of the methods proving satisfactory consists in increasing the natural acidity of the juice by the addition of phosphoric acid and liming back to approximately the natural acidity of the juice. Precipitated chalk can be used as a clarifying agent either alone or in place of lime with the phosphoric acid.

Utilization of fruits.—Studies at the Oregon station on the effects of time of picking on the canning quality of Italian prunes have shown that the best results as to appearance, texture, and flavor are obtained by picking the fruit when fully mature, but not overripe. The highest concentration of sirup and lowest acidity were obtained from the late pickings. Contrary to expectation, the riper the fruit the greater the loss in weight on canning (or fruit cut-out) and the greater the shrinkage. The shrinkage was compensated for somewhat by the larger size before canning of the more mature fruit. Fruit picked when immature and stored at 66° F. until fully ripe gave excellent products on canning, thus demonstrating the possibility of shipping the fruit to eastern markets for canning purposes.

Detailed directions for the construction and operation of dehydrators for prunes have been published by the California station. The various steps in the operation are as follows: "Lye dip as soon after harvesting as possible and rinse in fresh water. Separate into two or more size grades when traying. Enter in cooler end of dehydrator, preferably of air-blast type, at 120° to 140° F. Finish at a temperature not exceeding 165° and a humidity not exceeding 25 per cent. Store the thoroughly dried prunes in bins for at least two weeks before delivery to packing house, turning if examination reveals inadequate equalization." This station found that by crushing plums at a pressure sufficient to crush the pulp without breaking the pits the material is of the right consistency to be frozen in a cold-storage room rapidly enough to prevent fermentation. If frozen in 50-gallon quantities the pulp thaws so slowly that it can be shipped some distance without danger of spoilage. Methods have been developed for the utilization of the fruit thus preserved in the preparation of jellies, jams, candy, beverage sirup, etc.

Jelly making.—In connection with the extensive studies now being carried on at the Delaware station on factors controlling the jellying of fruit juices, an apparatus especially adapted for measuring the strength of pectin jellies has been devised. The principle involved in this apparatus is the displacement of air by water in a bottle and its transference to a syringe chamber and manometer. The energy required to force the syringe plunger into the jelly

is recorded on the manometer as a measure of the jelly strength. In testing jellies, two determinations are made, one in the glass and the other on the bottom surface of the jelly when turned from the glass. With the use of this apparatus it was found that the optimum points of jelly strengths followed the 1:2:3 ratio for sulphuric, tartaric, and citric acids. The minimum acidity for jelly formation appeared to vary from pH 3.7 for the organic acids to pH 3.55 for sulphuric acid. The optimum points for the three were pH 3.1 for sulphuric, 3.2 for tartaric, and 3.3 for citric acid. Previous observations that tartaric acid produces the strongest and most desirable jelly of the fruit acids were confirmed. Tests with varying quantities of sugar showed that at a given pH a definite pectin–sugar ratio must be maintained in order to obtain a jelly of optimum strength. In a jelly containing 1 gram of pectin, a 69.44 per cent concentration of sugar produced the maximum jelly strength and for 2 grams of pectin the optimum concentration was 66.66 per cent. Beyond a concentration of pectin representing 0.97 per cent of the weight of the finished jelly cloudiness and an undesirable texture resulted. Concentration of the pectin in the presence of acids before adding the sugar decreased the strength of the jelly, while boiling after the addition of sugar was without appreciable effect. Decreasing the temperature of the jelly increased its strength.

Removal of garlic odor and flavor from milk.—At the Tennessee station a successful method adapted to home or farm use has been developed for removing onion or garlic odor and flavor from milk. The method consists simply in shaking the milk with a purified mineral oil, removing the oil by filtration through several thicknesses of cotton cloth and repeating the process once or twice, depending upon the fat content of the milk and the intensity of the flavor. A total amount of oil about one-tenth that of the milk is generally sufficient. It has been shown that no change takes place in the composition of the milk beyond a slight loss in fat. The method is not applicable to butter, but cream from milk which has been thus treated can be made into butter as readily as cream from untreated milk.

Relative food value of proteins.—The Illinois station found the supplementing values of proteins of various foods of animal origin, for the deficient proteins in wheat flour, when fed in the proportion of 1 part of animal protein to 2 parts of the wheat-flour protein, to be, in decreasing order, as follows: Veal, milk, whole eggs, egg yolk, and egg white.

Vitamin studies.—In addition to studies of the vitamin requirements of farm animals (see pp. 61, 64), a number of fundamental vitamin studies of general application are being conducted at various stations as follows:

Irradiation as a means of introducing a sufficient supply of the antirachitic vitamin into foods was studied by the Pennsylvania station. Each ingredient of the basal ration heretofore used at the station in experiments with rats was irradiated and the extent of increase in antirachitic properties of the ration was tested by determining the ash content of the bones of the rats which had received the ration for 14 days. It was found that dextrin was the only constituent of the basal ration to become active on irradiation, but that equally good results could be obtained by irradiating a vegetable oil, such as corn oil, and adding it to the extent of 2 per cent of the unirradiated ration.

That the antineuritic vitamin and the growth-promoting water-soluble vitamin are not identical is thought to have been demonstrated at the Indiana station by carefully controlled feeding experiments on baby chicks. These and similar experiments are thought to demonstrate that yeast is deficient in the antineuritic vitamin and rich in the water-soluble growth-promoting vitamin and that corn is rich in the former and deficient in the latter. Experiments with rats at the Illinois station showed that the ingestion of excessive quantities of vitamin B did not modify appreciably the basal metabolism. From this it is inferred that there is no advantage from the standpoint of vitality as measured by the basal metabolic rate in providing more vitamin B in the diet than is required for growth and well-being. Investigations at the Pennsylvania station of the vitamin B content of evaporated milk manufactured by the commercial vacuum and aeration processes from fresh milk of known vitamin content led to the conclusion that vitamin B is not readily destroyed by the customary evaporation methods.

In attempts to determine whether the destruction of the antiscorbutic vitamin C in corn and cabbage in the

manufacture of silage and sauerkraut is due to the action of microorganisms, the Wisconsin station found that prolonged contact with air rather than the action of fermentative microorganisms is responsible for the disappearance of the vitamin. The Kansas station found that fresh pears contain an appreciable amount but are not a rich source of this vitamin. The antiscorbutic properties of pears were destroyed by canning either by the cold-pack or the open-kettle method but not by storage in the cold (40° F.).

An attempt to increase the antirachitic properties of cow's milk by irradiating the cows was made at the Maine station. As judged by feeding experiments with baby chicks, the milk of the irradiated cows was richer than that of the nonirradiated in the antirachitic vitamin, vitamin D. It has been suggested that cow's milk produced especially for infant feeding should be from cows having access to ultra-violet light either from the sun or some other source. The Wisconsin station has been unable to demonstrate an increase in antirachitic properties of cow's milk by irradiation of the cows, but has done so with goats. The Kansas station found that increase in antirachitic properties of milk resulting from irradiation of the milk itself may be accompanied by a sufficient loss in vitamin A to offset the gain in nutritive properties brought about by the increase in the antirachitic vitamin D. The Minnesota station states that breast milk from women on diets furnishing an abundant supply of green vegetables, fruit, eggs, and milk supplemented by a small dosage of cod-liver oil daily has been found to have definite antirachitic properties.

Hydrogenated cottonseed oil has been shown at the Minnesota station to be rich in the reproductive vitamin E, thus proving that this vitamin is not destroyed by hydrogenation.

Studies of vitamins in relation to reproduction, at the Arkansas station, showed that the oils extracted from wheat embryo, yellow corn, and hempseed furnished sufficient vitamin E to insure reproduction in rats. Cottonseed oil or olive oil likewise provided for normal fertility, but coconut oil, linseed oil, and sesame oil were not effective. Normal litters were born, but the young were dead, when the rations were supplemented with 20 per cent of wheat germ previously extracted with ether. A liberal supply of vitamin B in the ration was necessary to enable the mothers to produce sufficient milk to raise the young to weaning. Similar results were obtained at the Missouri station, especially with reference to the existence of reproductive vitamin E and its necessity for reproduction and the increased vitamin B requirement for lactation. At the North Carolina station rats fed rations of cereals alone failed to reproduce, but when the rations were supplemented with 5 per cent of alfalfa meal the young were successfully reared.

Iron in nutrition.—New light has been thrown on the question of the availability of inorganic as compared with organically combined iron for hemoglobin building by a demonstration at the Wisconsin station that anemia can be prevented in rabbits on a milk diet by the use of 0.015 gram daily of iron oxide supplemented by certain iron-free materials such as chlorophyll and alcoholic extracts of dried cabbage and corn meal but not by iron oxide alone. The probability is suggested that certain natural foods contain, in addition to the constituents hitherto recognized, an unknown substance which is essential for hematin formation.

AGRICULTURAL ENGINEERING

Marked progress was made in work in agricultural engineering at the stations during the year.

MACHINERY

Traction.—In a laboratory study to determine the laws governing the traction of wheeled tractors using lugs in a sandy soil, the Alabama station found that the greatest factor in the transmission of force from any lug is the complete utilization of the arch action of the soil. Other factors remaining constant, the output was found to be proportional to the depth of lug within the range of lugs studied and varied but slightly with the width of lug. A solid angle-iron lug gave the best results in loose soils having slight arch action. In soils where there was appreciable arch action, sharp spade lugs showed an advantage. The spacing of spade lugs was found to depend upon the arch action of the soil, which in turn was governed by the confining and compressing action of the rim. The angle of lugs across the rim had little effect upon output. The highest tractive efficiency was produced by a wheel weighted just sufficiently to force the lug into the soil.

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Prevention of corrosion in machinery.—The California station found that all types of paints, greases, and noncorrosive preparations tested gave perfect results after one year's exposure in a dry atmosphere with the exception of metal lacquer and shellac. When exposed to a moist briny atmosphere the heavy greases, vaseline, paints with graphite or graphite and red lead bases, and a mixture of white lead and tallow gave excellent protection. Heavy oils and natural asphalt base paints gave only fair protection, and light oils gave even less protection.

Crankcase oil purification.—The Alabama station reported the development of a two-stage method for purifying used tractor crankcase oil. In the first stage of this method the solid matter is removed, the process consisting essentially of washing with hot water containing washing powder in solution. In the second stage the absorbed motor fuel is removed to restore the oil to its proper viscosity by placing the cleaned oil in a tank in which it is heated to a temperature of from 350° to 380° F. and steam blown through it to remove the heavy ends of the fuel. When the steam passes through and opens up the mass of liquid, the fuel ends are readily and completely removed.

Silo fillers.—Silage-cutter design by the Minnesota station established the practicability of the four-knife flywheel machine when its moving parts are properly synchronized. The results indicated that cutters smaller than 12 inches are as a general rule uneconomical to operate.

Threshers and harvesters.—According to the Washington station the static electricity in stationary threshers occurs between the straw and the machine rather than between the parts of the machine, and the problem is rather to neutralize the static in the body of the machine than to ground the machine. There appeared to be some relation between static conditions and humidity, which may point to a means of controlling smut explosions.

Wheat losses behind the cutter bar of a binder and of a combine were about the same, averaging about 0.75 bushel per acre, according to observations by the Illinois station. The loss around the shocks averaged about 1 bushel per acre, and this was eliminated entirely by the combine. The saving in threshing of soy beans with the combine was much greater than by any other method of harvesting and threshing, even though the total loss was considerably higher than that in harvesting wheat.

The greatest percentage of waste caused by the cut-and-thresh method of harvesting soy beans for seed was found by the Virginia station to occur during cutting and shocking, the next greatest during the curing period. The waste with the row harvester was about double that with the cut-and-thresh method.

Fertilizer distributing machines.—Results of experiments by the Iowa station showed that for best germination under all conditions of climate and soil the distribution of fertilizers in direct contact with the seed either in the hill or in the row, is not advisable, and that planters with fertilizer attachments so designed as to cause such direct contact should be redesigned. The results obtained indicated the advisability of using a combination fertilizer grain drill in fertilizing cereals like oats and wheat and that a design of attachment is needed to guarantee the sides location of the fertilizer for all machines sowing seeds in wide rows or in hills.

Feed grinders.—Experiments at the Iowa station indicated that a small electric motor can be used for feed grinding, that time control is practicable, and that quantity control is easily arranged. The small grinder was found to have as high an efficiency as larger grinders, and the use of magazine bins saved labor.

Seeding machinery.—The California station found that grain treated with copper carbonate dust flows more slowly through grain drills than untreated grain, and that the percentage of retardation varies with the variety of wheat and with the amount and kind of treatment. The speed of the drill and the shape, size, and fullness of the seed box affected the rate of seeding only slightly.

Machines for insect control.—The California station developed a new machine to combat the grape leafhopper, which blows calcium cyanide dust in and through four nozzles placed so as to direct the dust upward, downward, and sidewise under a tent. The whole outfit is carried on a framework built upon a tractor which carries the assembly and drives the duster.

It was found by the Ohio station that the corn borer can, in a measure, be controlled by machinery which simply combines machine elements now used in independent operations without

a material increase in cost of harvesting over present methods. Experiments with both the cutting and shredding types of husker-shredder indicated that the borer mortality computed early in the following spring ranged from 95 to 100 per cent. Crushing stalks under extremely high pressures between two large corrugated rollers was not effective in destroying the borers, neither was plowing under of the crop residues.

STRUCTURES

Poultry house heating, lighting, and ventilation.—The Nebraska station found that the best egg production for a representative period of two months was obtained in a house with a minimum temperature of 60° F. Use of electric lights increased egg production.

The Washington station found that there was practically no difference in winter, especially during the cold weather, in the temperature and relative humidity in two poultry houses of equal size, one with and one without a straw loft. However, during the warm weather the straw-loft pen was about 5° cooler than the pen without a straw loft. During the winter months the temperature and relative humidity of open-front houses averaged about 5 per cent higher than those outside. During the summer months they were about the same.

Carbide gas was found by the Indiana station to be a satisfactory source of heat for operating an incubator.

IRRIGATION

Soil moisture capacity.—The California station found a normal moisture capacity and a maximum moisture capacity in soils, representing the minimum and maximum amounts of water retained by the soil when the water is applied at the surface and is free to move downward through the soil mass. At normal moisture capacity the soil water is readily available to plants but is not free to move under normal film forces, whereas at maximum moisture capacity the water is free to move under film forces.

Duty of water.—The best duty of water for alfalfa was obtained, by the New Mexico station, from about 50 inches of water applied in 5-inch irrigations, and for wheat from about 15 to 20 inches applied in 4-inch irrigations. The duty for miscellaneous crops varied widely with the crop, and the yields of most of the crops seemed to be more closely correlated with the amount of water applied than with the soil type. The yield of alfalfa per acre-inch decreased with the quantity of water applied. The Oregon station obtained best results from 12 to 14 acre-inches per season for cereals, 18 to 20 acre-inches for alfalfa, 18 acre-inches for clover, 30 acre-inches for Mammoth Russian sunflowers, 14 to 16 acre-inches for field peas, 18 acre-inches for peas and oats, 10 acre-inches for potatoes, and 12 acre-inches for beets and mangels.

Young prune trees grown on clay loam soils at the California station used water at the same rate per unit leaf area when the atmospheric evaporating power was the same and when the soil moisture content was reduced almost to the wilting coefficient as when the soil was filled to its maximum field or capillary capacity. The results were taken to indicate that the use of water by these trees was not influenced by differences in the amounts of water available for growth, and that optimum moisture conditions for growth cover a range of soil moisture from the maximum field or capillary capacity to about the wilting coefficient.

Time of irrigation.—The Washington station found that yields of alfalfa were not noticeably increased or decreased by fall irrigation. However, corn irrigated in the spring before planting produced an average yield of 61.5 bushels per acre as against an average of 49.8 bushels per acre for fall-irrigated corn.

Irrigation methods.—The New Mexico station found that shorter lengths of plats with a small irrigation head required about one-fourth less water to produce about 10 per cent less alfalfa than longer plats. About 12 per cent more alfalfa was produced per acre-inch on the shorter plats than on the longer.

Irrigation borders, according to the Oregon station, should be constructed from 30 to 40 feet wide and from 150 to 200 feet long, depending upon the head of water available, the character of the soil, and the topography of the land. To avoid loss from percolation, coarser types of soil should not be irrigated with more than 3 inches of water, medium types with not more than 4 inches, and finer types with not more than 5 inches per application.

Well capacities.—Experiments by the Montana station indicated that there

is no apparent definite relation between the amount of water a well will yield and its diameter. There is, however, a definite relation between yield and the draw-down. There was no indication that in new pumping districts dug wells of large diameter will give a greater yield than drilled wells.

DRAINAGE

Ground water level.—The Michigan station observed considerable differences in the moisture content of the well-drained sandy soils of the State, which may at certain times be as low as 1.5 per cent in Grayling sand. The water content of all the soil types studied was found to be fairly constant at depths of from 3 to 5 feet, and very little of the summer precipitation penetrated to these depths. The greatest fluctuation in the water content appeared to be in the surface horizon. This station also found that, generally, when the water level in muck soils averaged a depth of 4 or more feet during the growing season, lower crop yields were obtained than when it was at a less depth. For most crops a water level averaging around 3 feet was found to give the best results, while for some crops, notably celery, a lesser depth produced higher yields.

Soil moisture movement.—In experiments on cultivated corn soil at the Wisconsin station, the moisture penetrated to a depth of 12 to 18 inches in medium sand 24 hours after a 0.58-inch rain, but was almost wholly confined to the 6-inch depths of fine sand and sandy loam. Eight days after the rain its effect in the medium and fine sands disappeared, but was evident at the 18 to 36 inch depth of sandy loam.

SANITATION

Sewage disposal.—The Illinois station found that considerable improvement in the purification of the effluent of farm septic tanks was obtained by adding another chamber to still further treat the effluent from a preceding chamber. Erratic results were obtained in the small chambers of the three-chamber tank. A two-chamber tank appeared to be more efficient than a three-chamber or a single-chamber tank of equal size.

POWER

Horse power.—The Iowa station found that it is possible for a horse to exert a tractive pull of more than his weight, and that the ability of horses to pull depends upon their strength and available footing. It was shown that a horse in continuous work can exert a tractive pull of one-tenth of his weight while traveling 20 miles each day without intense fatigue except when it is extremely hot and humid. A significant feature of the horse as a motor is the overload capacity for a short period, which runs as high as 1,000 per cent for a short pull of 10 seconds. The Illinois station concludes that seven and eight horse teams will prove of practical size for plowing and other field work on many Illinois farms. Eight horses are apparently handled about as easily in the field as are five.

Electric power from central stations.—The New Hampshire station considers that the dairy farm offers the greatest possibilities for electrification in that State, with the poultry farm a close second, but that the general farm apparently has a chance to displace one or both. The fruit farm, if operated solely as such and carrying no stock, appears to offer the least possibilities for building up an electrical load.

A very small percentage of Virginia farms have electrical service from central plants, according to the Virginia station. Dairying uses more electricity than any other type of farming. The farm peak load comes in September and is due largely to pumping water. Electric irons are the most popular appliance, followed in order by water systems, vacuum cleaners, and washing machines. Appliances were found to be much more numerous on farms having central station service than on farms having service from individual plants.

Rural customers in Alabama are, according to the Alabama station, using electrical energy at the rate of slightly more than 1,000,000 kilowatt-hours per year. Of this amount, 453 farmers were using 33.1 per cent, 95 community enterprises 31.1 per cent, and 1,332 nonfarming residents 35.8 per cent. Of the energy used by individual customers, not including community enterprises, 95 per cent was used in the homes and 5 per cent as farm power. Of that used in the homes, slightly over 50 per cent was consumed in electric ranges and the remainder for lighting.

Electric dairy sterilizers.—A new type of electric heater for dairy sterilizers which operates on the thermosiphon principle was developed by the California station. This heater requires a

minimum of water and at the same time the heating element is submerged to a considerable depth.

Electric ranges.—In studies of electric ranges the Iowa station found that, on the closed type of unit, water is heated at the least cost with aluminum teakettles, while with the open type of unit the copper and nickel teakettle is the most economical. Use of an insulated cooker unit in cooking beef roast required less than half the amount of fuel used by the oven. An oven with little insulation required about twice as much fuel to bake potatoes as a heavily insulated oven. Without careful planning, a large amount of fuel may be wasted in preheating the oven to a baking temperature.

Electric lights for poultry houses.—Cost of electric power for lights and for extra feed consumed was relatively small as compared with the increased returns when electric lights were used in lighting poultry houses to lengthen short winter days, in experiments reported by the Oregon station. The cost of installing the lights was a more important item of expense. Electricity for brooding was found to cost more than oil but eliminated much of the labor and most of the fire hazard.

Electrical dehydration.—The capacity of a dehydrator for prunes and nuts was found by the Oregon station to be approximately doubled by recirculating part of the heated air with an electric fan, and less fuel per ton of dried product was used. The operation of the dehydrator was also under better control, and the dried product was usually of better and more uniform quality. The construction cost of dehydrators per ton capacity was found to be less for the recirculation type than for the natural draft type. The use of electric motors for driving the fans was found to insure greater reliability for continuous service and lower cost for labor. The use of electrical energy for operating the other parts of the dehydrator also saved labor and resulted in a better product.

Electrically heated walnut dehydrators compared favorably with both gas and oil-heated units, in experiments at the California station. While the labor and fuel costs increased the cost of operation of the electrically heated plants, the low cost of accessories and power more than offset this difference.

Electric feed grinding.—The Oregon station found that the electric power required for grinding feed with mills now on the market averaged a little more than 0.5 kilowatt-hour per 100 pounds of grain. Feed could usually be ground in less time than it could be sacked, hauled to town, and returned.

Electric hay hoists.—An electric hay hoist will replace a team and possibly an extra man and horse, according to results reported by the Oregon station. The power used in putting hay in the barn was found to be less than 0.5 kilowatt-hour per ton. The power required by a satisfactory and inexpensive hay hoist should not be more than five horsepower and preferably not more than three horsepower.

Wind-driven electric light plants.—The airplane propeller wheel is apparently an improvement in most respects over the old type of windmill wheel for wind-driven electric light plants, according to the Iowa station, although the output of current over a three-months period was found to be somewhat less than from the old type of wheel. Apparently the propeller may be somewhat more efficient in high winds than the old type wheel but it is much less efficient in low winds because it can not utilize winds with a velocity below 10 miles per hour.

Electric brooders.—The California station found the power consumption of electric brooders to range between 0.211 and 2.75 kilowatt-hours per chick, with an average brooding season of 1,000 hours. The heat distribution was better under the convection type of brooder than with the radiant and reflector types.

MATERIALS

Concrete.—The Minnesota station found that high alumina cement concrete reaches its ultimate strength in about seven days, and that thereafter the strength remains constant. The necessity for a hardening period for all high alumina cement concrete exposed to the action of sulphate waters was indicated. The high alumina cement was somewhat more resistant than most standard Portland cement to the action of sulphate waters. It was not feasible to mix alumina cement with standard Portland cement except within very narrow limits. Other studies by the station showed that no matter how well cured in water, concrete must subsequently be allowed to dry thoroughly and harden before being exposed to the action of sulphate-bearing waters if great resistance to attack is to be expected.

The addition of powdered blast furnace slag to concrete up to 40 per cent by weight apparently had little or no influence on the strength and absorption, although the resistance to sulphate waters was increased to a degree closely proportional to the quantity of slag added. The addition of ironite up to 10 per cent of the weight of the cement had a similar effect. The life of the cement in sulphate solutions was increased about 20 per cent by adding 4 per cent of calcium chloride. The use of a siliceous material in the form of volcanic ash as an admixture increased the life of the cement nearly 70 per cent when as much as 20 per cent by weight of the cement was added. Both high calcium and high magnesium hydrated lime in proportions of 5 and 10 per cent and water-gas tar in the proportion of 5 per cent gave negative results. Twenty per cent of water-gas tar caused a loss in strength of more than 50 per cent, although the life of the specimens in the sulphate waters was increased about 50 per cent.

Draintile.—The Minnesota station found commercial concrete draintile to be subject to disintegration by the ordinary sulphate salts found in some soil waters in quantities exceeding about 0.15 per cent. The severity of action on concrete tile of pure solutions of sulphates of magnesium and sodium was found to be somewhat proportional to the strength of the solutions up to 1 per cent. Solutions of from 1 to 9 per cent did not greatly hasten the action.

Fence posts.—Experiments in which water-gas tar was used in varying proportions with creosote as a timber preservative at the Iowa station indicated practically no failures in cottonwood posts. The Arkansas station found that galvanized metal posts showed no deterioration in the third year, but painted metal posts showed rust where scratched. Untreated oak posts and posts treated by dipping in creosote showed decay at the ground line. Commercially treated pine posts showed no decay. The Missouri station found that posts given a five-hour double tank butt treatment in creosote and having the tops painted with hot creosote were all good except the soft maple and sycamore posts, which failed after two years.

Rammed earth.—Moisture content and the rate of putting the earth into the molds were found by the California station to be factors influencing the strength of rammed-earth structures. No great difference was observed between the strength of fine sandy loam and clay loam material. Fine-grained sedimentary soil with a high colloidal content acted differently from other soils under stress. The rate of drying was found to be an important factor in the ultimate strength of rammed earth as well as in the effect of straw in reinforcing. An elastic limit of this material was observed in compression tests which was most marked in a fine sandy loam.

LAND CLEARING

Stump removal.—The total cost, including clearing, of a cord of stump-wood fuel, tightly piled, was found by the Minnesota station to be about $4. This included labor, 57 per cent; blasting material, 31 per cent; and power, 12 per cent. The Alabama station found that with the cost of explosive the same per pound the final cost of removal per stump was nearly doubled for each increase of 3 inches in diameter. In loose, friable, and soft soil of low free-water content the blast was forced into the earth by heavy-rooted hardwood stumps. An extra large charge heaved the soil through the roots and left the stump intact. With a high free-water content the soil acts as a shoulder for the force of the blast to lift against, and the line of expansion of the blast is upward after a relatively small downward and lateral expansion. Twenty per cent ammonia dynamite with a speed of 9,600 feet per second was found by the Alabama station to be too slow for stump blasting in dry soils. The most satisfactory explosives were the 30 and 40 per cent dynamites having speeds of 12,000 and 14,000 feet per second, respectively. All of these explosives were satisfactory in wet soils.

Stump burners.—The California station developed two kinds of stoves for burning stumps, viz, the so-called California stove, which is a return-flue type which burns the stump from the inside by first burning a hole in the stump, thus causing it to become its own stove, and the barrel-type stove, especially for hardwood stumps, in which the roots are blasted out and the stump split sufficiently to cause it to dry. It is then burned out with a can over the top. The cost of clearing land of oak stumps from 6 to 18 inches in diameter with this method was considerably less than with the pulling method.

FARM FIRES

Fire-fighting equipment.—The Alabama station demonstrated the value of the pressure water supply tank for fire fighting. The $\frac{5}{16}$-inch nozzle outfit was found to be the most desirable.

Spontaneous combustion in hay.—The seat of the heating and subsequent ignition of green hay in the mow was found by the Pennsylvania station to be in a cone of compacted hay under or nearly under the point where the hayfork dropped the hay. Tearing apart and spreading the hay as dropped by the fork secures better ventilation and prevents the forming of such heat pockets.

SOIL EROSION

Run-off and erosion.—The North Carolina station cooperating with this department showed that run-off from a fine sandy loam soil is apparently proportional to the intensity and the amount of rainfall rather than to the amount alone. The average run-off was found to be 35 per cent of the rainfall and the maximum for a single rain was 64 per cent. Erosion followed the same rule to some extent, although the principal controlling factors appeared to be cultivation and the character of the vegetative covering of the soil. Fifty per cent of the annual erosion occurred during June when cultivation was carried on and before the crops had made material growth. Grass sod was found to be strikingly efficient in decreasing both run-off and erosion. Corn also showed a beneficial effect in both respects, whereas erosion was increased with cotton. The total run-off from cotton soils was greater than that from the bare soil.

ECONOMICS AND SOCIOLOGY

Taxation.—The Kansas station found that taxes per acre on farm real estate increased from 0.53 per cent of the selling price in 1910 to 1.01 per cent in 1923, and on city real estate from 1.07 per cent to 2.29. Education was responsible for 63.9 per cent, and roads and bridges for 21.3 per cent of the increase in the average tax levy between 1916 and 1918 and 1921 and 1923 on farm real estate. In the case of city real estate 63.7 per cent of the increase was due to education and 8 per cent to roads and bridges and alleys. The total levies for administration decreased on both types of real estate, the decrease for farm real estate being 6.2 per cent of the total increase of all levies and that for city real estate 2.6 per cent. Increased expenditures for specific improvements and service which the public demanded rather than "increased cost of government" have been the cause for the increase in the ratio of taxes to selling values of both types of real estate.

Taxes on agricultural lands in Texas increased over 120 per cent from 1914 to 1923. A study made by the Texas station showed that the State and local district taxes have increased 129 and 156 per cent, respectively, since 1914, as compared with 90 per cent for county taxes, and that in 1923 more of the State levy was used for public schools and pensions and a greater proportion of the district levy for roads than in 1914. Of each dollar of taxes levied in 1923, 35.1 cents was for State purposes, of which 23.1 cents was for schools, 7.4 cents for benevolence, and 4.3 cents for administration; 36.5 cents was levied for county purposes, of which 16.2 cents was for administration and 20.3 for roads; and 28.4 cents was levied for local districts, of which 16.4 cents was for schools and 12 cents for roads. It is pointed out that an element of serious danger exists in the large State levy due to the absence of any central equalizing body to establish a uniform relation between the assessed and the true value of rural lands throughout the State.

Loans to farmers.—Farm real estate mortgages were found by the Arkansas station to comprise 54 per cent of the total loans to farmers and farm owners in that State. Federal and joint-stock land banks made 39 per cent of such loans, farm mortgage companies 21.5 per cent, and commercial banks 11.7 per cent. Commercial banks are carrying 67.1 per cent and merchants and others 31.6 per cent of the short-time loans made to farmers. Of the Federal and joint-stock land bank loans approximately 79 per cent were made to pay mortgages and other debts and 7.5 and 8.5 per cent, respectively, for the purchase of lands or for buildings and improvements. Of commercial bank loans, 42.4 per cent were made on mortgages of real estate, livestock, and crops; 16.1 per cent on real estate alone; 7 per cent on livestock alone; and 34 per cent on personal indorsement, collateral, etc. The use of the different types of security, however, varied greatly in different parts of the State. Some of the factors causing the high rate of interest in

the State were found to be the sharp fluctuations in the annual value of farm crops, the one-crop farming system, the large capital requirements necessary for cotton and rice as compared with more diversified crops, the large number of small banks, the small average size of loans resulting in high overhead charges, and the State's method of financing highways, which has naturally reduced the margin between appraised valuations and the loans on farms.

Profits in farming.—Variation in the value of tobacco per acre due to yield and quality was found by the Virginia station to be the most important cause for the differences in earnings on different farms. Area in tobacco, income from supplementary enterprises, and good returns per acre from supplementary crops were also important. Quality and yield of tobacco were affected by the quantity of fertilizer applied, and the building up of the soil by proper rotation and the growing of legumes was found to be one of the most effective ways of increasing farm returns.

The productive work units per man, the ratio of expenses to receipts, the volume of sales per hundred acres, crop yields, and the ratio of value of feed fed to returns from livestock, were found by the Kentucky station to be the major factors in influencing profits on 270 farms in Union and Henderson Counties. Scoring the farms for strong points—a point being given where a farm was 10 per cent better than the average for one of the above factors—showed the net earnings for the 52 farms having no strong points to be minus $474, whereas those for farms having one to five strong points each were $80, $343, $1,018, $1,699, and $2,062, respectively.

The production per animal unit, efficiency in the use of man labor, value of real estate, crop yields, and the amount of pasture used to carry one animal unit were found by the Iowa station to be the most important factors in the profits of 231 Warren County farms.

Farm tenancy.—In 1920, 25 per cent of all farms in Virginia were operated by tenants, the percentage in some counties exceeding 50 per cent. With a view to assisting in bringing about fair contracts from the standpoint of the owner, tenant, and the future of the agriculture of the State, the Virginia station summarized the obtainable data regarding the types of tenancy in the State and the chief practices under each type. Recommendation is made that all leases be in writing and for a sufficient term to encourage the tenants to build up the soil, that provision be made for payment to the tenant at the expiration of the lease for unexhausted improvements, and that definite plans for soil improvement by crop rotation and the application of fertilizer and lime be outlined.

A survey of 1,034 farms made by the Nebraska station showed that the most common routes to farm ownership were as follows: Farm boy, tenant, owner 29.7 per cent; farm boy, hired man, tenant, owner 25.2 per cent; farm boy, owner 14.8 per cent; and farm boy, hired man, owner 5.5 per cent. Less than one-sixth of the tenants studied owned land and about two-thirds expected to become owners.

Roadside markets.—Fifty-nine out of 100 farmers' roadside stands studied by the Maryland station during the summer and fall of 1925 had seasonal sales of from $100 to $500. Average weekly sales of $20 for temporary stands, and total yearly sales of at least $3,000 for permanent stands were necessary to justify their operation. Thirty-six per cent of the 100 stands charged less than city retail prices, 36 per cent charged city retail prices, 8 per cent charged more than city prices, and 20 per cent were irregular as to their prices.

Cooperative marketing.—Marketing costs in 1922 in 19 cooperative livestock marketing associations studied by the Nebraska station ranged from 6.56 per cent of the total receipts for hogs to 8.6 per cent for calves; terminal charges varied from 1.93 per cent of the gross receipts for hogs to 4.15 per cent for calves; transportation charges from 3.49 per cent for sheep to 4.38 per cent for cattle; and local expenses from 0.87 per cent for calves to 1.11 per cent for sheep.

Cooperative shipping associations studied by the Wisconsin station paid approximately 92 cents out of each dollar of gross receipts received in 1923 to the producers, as compared with 72 to 75 cents paid by local buyers. Cooperative commission firms by patronage dividends were found to have reduced commissions from 20 to 35 per cent.

The cooperative cream pools, the organization of which began in Idaho in 1922, were found by the Idaho station to have made steady growth in

number, membership, and volume of cream handled. The pools have reduced the number of stations or buyers in their territories from an average of 3.6 to 1.4. During 1925 the weighted average cost of operating the stations of the pools per pound of butterfat was 2.11 cents, and the average price paid per pound of butterfat was 4.7 cents above that of the local stations. The quality of the cream handled in three of the larger pools had gradually improved each year,

Marketing of cream.—The establishment of sweet cream as the standard for first-grade cream, payment for cream on the basis of the price of butter produced, the development of a large volume of high-quality sweet-cream butter to be sold under a one-brand name, and the formation of a creamery federation to improve manufacturing methods and eliminate unfair and unsound practices were the recommendations made by the Oregon station as the result of a study of the marketing problems of the creameries of that State.

Tobacco production in the Connecticut Valley.—A study made by the Connecticut Storrs station showed that while cigar consumption, especially of the grades using Connecticut Valley tobacco, had fallen off greatly, the production of tobacco in the valley had increased until the number of years' supply in the hands of dealers and manufacturers on July 1 had increased from 1.3 years in 1918, 1919, and 1920, to 2.6 and 2.8 years' supply in 1924 and 1925. Immediate readjustment of production was advised before increased stocks should reduce prices, contract credit, and force reduction of the tobacco acreage.

Berry farming in Washington.—Berries alone were found by the Washington station to be less profitable than berries and poultry combined and more profitable than berries and dairying, in a study made by the station of berry farming in the western part of the State. The average cost of producing a pound of berries in 1923 and 1924 was 4¼ cents for blackberries, 6⅔ cents for strawberries, and 8½ cents for raspberries, the raspberries being produced at a loss. The most successful farms were those having over 70 per cent of their capital invested in land utilized as fully as possible.

Massachusetts apple industry.—The Massachusetts station, in a study covering the farms growing 75 per cent or more of the marketable apples of the State, estimates that within the next 15 years the commercial apple production of the State will be doubled and that within 10 years approximately 50 per cent of the crop will be produced by 100 growers. With the existing outlook, it is of utmost importance that new markets be found or created; that attention be given to grading, packing, and marketing in order to meet competition; and that a strong organization be formed for advertising, marketing, and creating or finding new markets.

Cost of production of peaches.—The Arkansas station found the cost per acre of developing peach orchards to bearing in that State, including interest and the value of the land, to be $112 in the Ozark foothills and $121 in the Highland district. The total cost per acre for the estimated 15-year bearing life of an orchard was found to be $1,119 and $1,493, respectively, for the two regions. The average cost of producing, harvesting, and delivering peaches packed for shipment, based on 1925 cost receipts, was 93 cents for the Ozark district and 92 cents for the Highland district, the net receipts per acre being $87 and $110, respectively. Improvement in the quality of trees, cultural methods and marketing, and the bringing about of a more economical size of operating unit rather than increase of acreage, were indicated as the needs of the industry to enable it to meet future competition.

Cost of production of corn, cotton, and other crops.—Several States during the year reported results of cost-of-production studies. Cost records obtained by the Illinois station covering the period 1913 to 1922 in Hancock and Franklin Counties and the period 1920 to 1922 in Champaign and Piatt Counties showed that for the period 1920 to 1922 the net cost per bushel of producing corn was $1.30 in Franklin County, 48 cents in Hancock County, and 58 cents in Champaign and Piatt Counties; that of wheat $1.64, $1.05, and $1.16 per bushel, respectively; that of oats 77, 45, and 52 cents, respectively; and that of clover $9.15, $14.03, and $14.37 per ton, respectively. With these results as a basis four and five-year rotation systems were worked out by the station for the sections represented.

A study of cost of producing corn made by the Ohio station on 25 farms in Greene County during 1920 to 1924 showed that the average cost, including interest, of growing corn up to

harvesting was 46 cents per bushel; of growing and harvesting wheat and oats, 94 and 50 cents per bushel, respectively; of growing and harvesting hay, $11.46 per ton; and of producing clover and timothy pasture, $2.18 per animal unit per month. The cost of growing and harvesting alfalfa hay was about 30 per cent less than that for mixed clover and timothy hay. More than 42 per cent of the cost of growing corn was for labor as compared with 22 and 26 per cent, respectively, for wheat and oats, and of the total labor required for corn up to harvesting 70 per cent was for plowing and cultivating. The use of three and five-team plows for plowing and two-row cultivators was found to materially reduce the cost of producing corn. Charging labor at the average rate for regular labor, husking from the stalks cost 9.9 cents per bushel as compared with 11.2 cents for corn cut by hand and husked from the shock, 13.2 cents for corn cut with binder and husked from the shock, 10.4 cents for corn cut by hand and shredded, and 12.5 cents for corn cut with binder and shredded.

A one-year study made by the Mississippi station in Choctaw County showed the costs of production to be 15 cents per pound of lint cotton, 76 cents per bushel of corn, exclusive of rent, 41 cents per pound for butterfat, 28 cents per dozen for eggs, and 15 cents per pound for dressed pork. These results indicated that it is not advisable to use land and labor for corn that can be used for cotton unless the chance is as good of producing 15 bushels of corn as 100 pounds of lint cotton per acre.

Costs of producing range beef, mutton, and wool.—The costs per hundredweight of producing beef on the ranges of eastern Oregon were found by the Oregon station to be $9.27 for weanling calves, $8.70 for yearlings, $8 for beef cows, $9.75 for grass steers, and $11.50 for winter-fed steers. The cost per year of running a breeding cow on the range was $27.10, and for a mixed herd, $21.40 per head.

With wool at 40 cents per pound, it costs $9.24 for 100 pounds to raise feeder lambs and $9.90 per 100 pounds to raise early fat lambs in the same section. With feeders at $10, fat lambs at $10.50, fall prices, and wool 40 cents per pound, sheep paid $8 a ton for hay, $1.62 a year for grass and wages, and 8 per cent on livestock investment. The points of management having the greatest bearing on the profits from the sheep industry were size of band, adequate finances, size of lamb crop, and the wool clip per head. The study made by the station brought out that usually about 1,200 ewes can be handled satisfactorily, that reasonable profits of owners having less than a 50 per cent equity in the land and sheep will be absorbed by the high rate of interest required on loans, that a lamb crop of 85 per cent or more is necessary to insure success in the industry, and that while the Oregon wool clip averages over 9 pounds per head, averages of 12 pounds and over have been gotten from large bands by careful culling of ewes and the use of heavy shearing bucks.

Minnesota potato prices.—Most of the changes in the prices of potatoes were found by the Minnesota station in a study covering the years 1899–1924 to be explained by five factors, (1) value of the dollar, (2) the upward trend in the value of potatoes, (3) production in the late-crop States, (4) the price of potatoes in August, and (5) the variation in quality. The seasonal variation in the prices of potatoes in Minneapolis and St. Paul from 1899 to 1915 indicates that in an average season prices may be expected to be 3.8 per cent below the average for the season in September, 11.4 per cent below in October, then to increase to approximately the average in January, and to 11.1 per cent above the average in April, dropping again to 9.9 per cent above the average in May. It is probable that crops 20 and 10 per cent above the normal in the 27 late potato States will result in Minnesota prices being 29 and 17 per cent below the normal, while crops 10 and 20 per cent above the normal will raise Minnesota prices to 26 and 70 per cent above the normal.

Freight rates on agricultural commodities.—The New York Cornell station constructed an index number of freight rates based on 50 rates on 15 agricultural commodities, the average rate for 1913 being taken as equal to 100. This index number declined from a yearly average of 104 in 1900 to 101 in 1905, remained between 99 and 101 in 1906 through 1917, then rose rapidly to 177 in 1921, and dropped to 160 in 1922. The index numbers of the rates on wheat rose from 100 for 1913 to a yearly average in 1921 of 208 for the Eastern rate group, 167 for the Western group, 154 for the Mountain Pa-

cific group, and 190 for the west to east shipments. By August, 1923, the index numbers for the several groups had declined to 188, 143, 136, and 166, respectively.

Storage of grain for price increases.—Winter to summer storage of corn was found by the Iowa station to cost about 15 cents per bushel. The use of new rat and weather proof cribs reduced this cost to 12 or 13 cents per bushel. Year to year storage cost an additional 6 cents for crib, plus 0.5 cent per month for interest, insurance, etc., over the winter to summer storage cost. It was found that as a general rule where storage facilities have been provided they should be used whenever the feed production exceeds 104 per cent of the average.

A study of the Kansas City price of No. 2 hard winter wheat from 1892–93 to 1923–24 by the Kansas experiment station showed that there are definite tendencies in the wheat market in each month of the year. Three potential weak spots were apparent, namely, (1) June to August, inclusive, caused by the prospective and actual movement of the new crop from the winter wheat belt of the United States; (2) in November, caused by the movement of the new Canadian crop and the spring wheat crop of the United States; and (3) in February and March, caused by the movement of wheat from Argentina and Australia. Three potential strong spots were also apparent, namely, (1) in September and October, influenced by the decreased movement of hard winter wheat in the United States and from competing countries; (2) in January, attributable to the closing of navigation of the Great Lakes and the lack of competition from Argentina and Australia; and (3) in April, when Argentina and Australia have usually passed the peak of their shipments.

Cost of storing potatoes.—The combined cost of labor, building and site, equipment, office and management, and other direct costs were found by the Minnesota station in a study of 71 potato warehouses to range from 28.24 cents per hundredweight for houses handling 5,000 hundredweight to 18.57 cents for houses handling 80,000 hundredweight, a range of 9.67 cents per hundredweight of potatoes handled. The largest range was 3.40 cents for building and site cost, with labor second, at 2.80 cents.

Management of farmers' elevators.—Costs of operating 109 elevators in the Minneapolis-Duluth area for the crop year 1922–23 varied from 1.7 to 13 cents per bushel, averaging 4.7 cents, according to a study made by the Minnesota station. The cost of operating decreased rather rapidly as the volume handled increased up 125,000 bushels and gradually above that volume. Ninety-five per cent of the grain was bought for cash. Most of the gross trading profits were between 2 and 10 cents per bushel, averaging 6.7 cents. The average net gain of all elevators was 2 cents per bushel, although 21 had net losses amounting to as much as 4.6 cents per bushel.

Rural social organization.—The Washington station found that of the 36 rural neighborhoods studied only 6 had a high and 18 a medium evaluation of group consciousness. A strong group feeling was not found unless there was more than one factor or force—church, school, grange, cooperative organization, etc.—creating group consciousness.

Service institutions for town and county.—Rural living standards are materially affected by the high school, library, and hospital facilities available, but for such services the family is very largely dependent upon community control. The Wisconsin station, in a study made in eight towns ranging in population from 1,350 to 2,898 and the surrounding communities, found that high schools, libraries, and hospitals of good working unit sizes can be maintained with the population and other conditions, represented by the communities studied by service areas of 41, 133, and 200 square miles, respectively, with tax rates on the assessed valuations of such areas for local costs of 3.7, 0.5, and 1.1 mills, respectively.

METHODS IN FEEDING EXPERIMENTS [3]

By George Haines

Assistant in Experiment Station Administration, Animal Husbandry, Office of Experiment Stations

This paper is based on a study of the experiments, the publications, and the outlines of animal husbandry and dairy projects submitted for the use of Federal funds. It concerns mainly the standards, ideals, and methods as expressed in different types of feeding trials, their avowed purpose and the advances which they make possible.

Feeding experiments of a certain type frequently have been criticized. In 1908 a committee of the American Society of Animal Nutrition, composed of H. P. Armsby, H. J. Waters, J. H. Skinner, and H. R. Smith, made the following statement in regard to the early feeding work: [4]

"The earlier work in animal nutrition was perhaps of as high a grade as was feasible or justified when the insistent demands of the public for immediate and practical results and the limited funds and facilities are considered. When we come to study the results, however, with a view to deducing fundamental principles, we can not fail to be impressed with the imperfections of the work. The trials were mostly of short duration, and involved too small a number of animals. There is a notable lack of exact information regarding the breeding, quality, age, development, and condition of the animals used, and only within very recent years has any attempt been made at estimating the condition or finish of the animals at the close of a trial.

"The absence in this earlier work of a broad, well thought out and well correlated plan is noteworthy. The trials were usually limited to a comparison of two or more kinds of feed, or of varying amounts of the same feed, or a contrast of the gains made with feedstuffs when prepared in different ways. Little or no regard was had for the more far-reaching or fundamental bearing the results might have had upon the science of nutrition."

Fortunately there has developed since the report quoted was written a very large and highly credible amount of investigation directed primarily at the theory and practice of animal nutrition, which has made important contributions to the knowledge of the principles of nutrition, the constituents and special properties of various feeding stuffs, and the presence and importance of feed accessories, minerals, and the like, which probably has marked a greater advance in the scientific aspects and understanding of the subject than had been made in any similar period before. American investigators have had a large part in this advanced work. But the question is as to the effect of this investigation, and the enlarged viewpoint which it gives, on the common type of feeding experiment which does not aim to advance nutrition principles but rather to apply them in practice or test them in relation to certain feeds and rations. The number of feeding experiments of this kind has shown no decrease—actually it is much larger than it was 20 years ago and relatively it continues to constitute a large feature of animal husbandry work.

Feeding trials have been generally improved to a point where the criticism of the first paragraph of the committee report cited is no longer so applicable. The duration of the feeding trials has been considerably lengthened and now larger numbers of animals are included in the lots. It is seldom that an experiment is conducted for a shorter period or with fewer animals than would be representative of sound practice. It has become quite customary to repeat feeding trials at least twice. There are few experiments which do not provide for the greatest possible degree of uniformity in breeding, quality, age, development, and previous management, and in feeding among the animals in each lot and in different lots. The importance of these considerations is

[3] A paper presented at the meeting of the American Society of Animal Production at Chicago, Nov. 26, 1926.

[4] Armsby, H. P., Waters, H. J., Skinner, J. H., and Smith, H. R. report of committee on organization. Amer. Soc. Anim. Nutrition [Proc.] 1908: 3–13. 1909.

being more and more recognized. Animals are usually graded at the beginning and conclusion of a comparison as to condition and finish. Some recent projects also have taken into consideration the quality of the meat produced, not only from the standpoint of its characteristics after slaughter but also after ripening in the cooler and after cooking.

Feeding eperiments are still being carried on which are subject to the criticism of the second paragraph of the report quoted above. Some of these experiments are lacking in certain essential qualities of scientific investigation and at best give results of only limited or temporary value. Frequently they consist mainly of repetitions of tests which may be little more than demonstrations of the comparative value of individual feeds or of the experimenter's ability as a feeder. There still persists to some extent a certain type of feeding trial the primary object of which appears to be to stimulate popular interest and to enlist popular support. The need for such work at this stage may well be questioned. In most cases it appears to be merely a demonstration with little reason for confusing or classifying it with experimental work designed to discover new or fundamental facts.

One of the distinguishing features of scientific investigation is the skill displayed in discovering and classifying new facts so that they may be coordinated and interpreted in relation to established principles. Many feeding experiments fulfill this requirement, but there are still some which do not appear to take into account the more advanced state of knowledge. There are altogether too many experiments which appear to be poorly planned, poorly interpreted, and are expected to answer questions which they are not competent to answer in the light of our present knowledge. Equipment, methods, or technic inadequate for a task do not furnish an excuse for mediocre work. Critical judgment is necessary for deciding on an experiment which may be properly carried out.

Among the projects for which it has been proposed to use Purnell funds are included some feeding and management experiments which show little or no advance in grade or method, but propose to repeat with slight variations and without improved technic, experiments which have been made intermittently for many years. Too often they suggest in their preparation a lack of careful consideration of the actual objective and the possibility of its attainment in the experimert. They are not so limited in scope that definite information relating to a specific question may be expected.

Frequently project outlines are submitted which have as their purpose the solution of the problems in a wide field of investigation and involve many questions which should be taken up step by step. Examples of this are found in outlines for investigations on factors influencing the quality and palatability of meat. Some of these plans propose to determine in a single project the effect of practically all of the factors influencing the character of the product. Such broad projects, sometimes enumerating as many as 12 to 15 objectives, give little or no idea of what is to be done. A project having fewer objectives, but so planned that as few variables as possible account for all the differences between individual lots, is more likely to result in a permanent advance in knowledge.

It would seem hardly necessary to mention the importance of the control of variables and related conditions were it not for the fact that occasionally experiments are proposed which do not meet the requirements in this respect. Examples of this are found in experiments in which lots of animals are allowed a choice of feeds which are placed in separate self-feeders, no means being provided for recording the feed consumption of individual animals.

The importance of a clearly written outline of the exact scope, purpose, and procedure of a proposed investigation has been demonstrated and is generally recognized. Such an outline should have a specific title and should state definitely and simply the object of the experiment and how the variables are to be controlled, giving as much information as possible on the type of animals, rations, the methods of weighing and sampling, and a list of the data to be recorded. Detailed plans are particularly important for the use of assistants helping with the project and for the information of departments cooperating in the investigation. One of the most desirable and helpful purposes of such an outline is to establish in the investigator's mind the exact scope of the problem to be attacked, the method to be employed,

and what will be required for the work at the outset and as it proceeds.

In case of long-continued or repeated experiments it is especially desirable that rather frequent periodic summaries of the results obtained be made. These summaries will indicate where the results are leading, and the completeness with which the information collected is fulfilling the purpose of the project. The time at which the summaries are to be prepared should be planned in advance; otherwise they are likely to be put off under the pressure of other work until the project is completed. If the experiment is properly planned, many of the difficulties in conducting it and analyzing the results are minimized, but close observation throughout the experiment is necessary as an aid in the interpretation of the results.

The usual means of reporting the results of feeding experiments consist in comparing the relative gains in live weight made in different lots, and in calculating the average quantities of feed required per unit of gain. In certain more refined experiments, and especially those dealing with young animals in growth studies, measurements of various portions of the body are recorded. The market grade or relative selling price is also frequently included. More recently particular attention has been paid to the carcasses of the fattened animals and to the quality and palatability of the meat. This marks a distinct advance and indicates the probable future trend in animal husbandry experimentation.

The relative significance of the differences observed must be estimated and the meaning of the differences must be analyzed in terms of other known facts. One important aid in the interpretation of the results of feeding experiments, viz, the statistical analysis of the data and the determination of their actual range of variation and their probable error, has frequently been overlooked. In working with animals whose variable is an unknown quantity it is important to ascertain whether differences observed between lots are due to the variability of individuals or to the experimental treatment. Statistical studies by Mitchell and Grindley[5] of the gains made by animals in fattening experiments have indicated that the approximate average coefficient of variability for sheep is 21 per cent, steers and swine 17 per cent, and poultry 16 per cent, thus making it necessary to have from 20 to 30 animals per lot if it is desired to indicate a significant difference of 10 per cent between the gains of the lots. Cases of much greater variability have been observed which would necessitate much larger numbers per lot. Maynard and Myers found somewhat less variability in milk production in selected groups of dairy cattle.[6]

Biometry is beginning to be used in nearly all branches of agricultural experiments as an aid to the interpretation of their results. Statistical treatment of the data obtained in agronomic experiments, which are quite comparable with feeding experiments with animals, has been found a most valuable aid and has materially assisted in the progress of this type of work. Statistical studies of the results of feeding experiments should be of equal value.[7]

The procedure followed in a feeding experiment or investigation will naturally depend on the nature of the problem involved. There is no advantage in overrefinement in a simple comparative trial; it is far more important that complications be avoided, that the comparison be made as simple and direct as possible, with suitable checks, controls, and replications. It should find its justification in the need for it in the light of what is already known and the competence of the plan of the investigation to give a clear-cut, decisive result. Such trials may not contribute to the knowledge of the principles of nutrition, but if conscientiously planned and executed may give reliable results which have a tentative value for the condi-

[5] Mitchell, H. H., and Grindley, H. S. The element of uncertainty in the interpretation of feeding experiments. Ill. Agr. Expt. Sta. Bul. 165, pp. 463–579, illus. 1913.

[6] Maynard, L. A., and Myers, W. I. The refinement of feeding experiments for milk production by the application of statistical methods. N. Y. Cornell Agr. Expt. Sta. Bul. 397, pp. 211–249, illus. 1918.

[7] Of the numerous publications dealing with methods of measuring variability the bulletins of the Illinois and New York Cornell experiment stations, already referred to; a brief paper by H. H. Love on The importance of the probable error concept in the interpretations of experimental results (Jour. Amer. Soc. Agron., 15: 217–224, 1923); and Statistical methods for research workers, by R. A. Fisher (239 pp., illus., Edinburgh and London, 1925), deserve special mention. Student's method described in Love's paper depends on paired experiments and appears to deserve wider use in comparative feeding experiments.

tions they represent. On the other hand, feeding experiments which have the deeper or more far-reaching purpose of advancing the understanding of the principles of nutrition in practice, need greater refinement and greater care in planning. It is to be expected that they will be deliberate, purposeful, skillfully devised efforts to shed further light on questions remaining in doubt, or to answer new questions. Their studied aim ought to be to make as substantial a contribution as circumstances will permit.

The most obvious means of making advancement appears to lie in an improvement in the methods employed in conducting the experiments and in interpreting the results. There are still many phases of the methods used which are not based on sound scientific principles, and others which could be improved. Fundamental studies of methods would contribute more than continued repetitions of experiments by faulty methods. For example, in discussions of methods of weighing it has generally been recognized that fattened animals should be weighed on at least three successive days at the beginning and at the end of a feeding period. It is further specified that weighing should be done at the same time each day, preferably before watering. There seems to be a need for definite investigation, however, of the relative variability in weight of animals weighed at different times of the day. It is quite possible that weights taken after watering might be found less variable than weights taken at some other time. Recent advances in determining the quality of the fattened animal have already been referred to. While some valuable preliminary work has been done, there is a very definite need for further research to find and to measure the factors which determine quality and palatability of meat.

Particular attention has been called in this paper to the methods used in planning and conducting feeding experiments, particularly those of the simpler kind, in the hope that with further study and refinement in method and plan these experiments will yield results of more general and permanent value.

DEVELOPMENT OF HOME ECONOMICS RESEARCH AT THE AGRICULTURAL EXPERIMENT STATIONS UNDER THE PURNELL ACT

By Sybil L. Smith

Assistant in Experiment Station Administration, Home Economics, Office of Experiment Stations

PROVISION FOR RESEARCH IN HOME ECONOMICS

A survey of the status of home economics research in the agricultural experiment stations [8] made shortly before the Purnell Act went into effect showed that at only 4 of the 50 stations included in the survey was research being conducted in the departments of home economics, and that 17 stations were not engaged in any research which had direct application to home economics. In some of the States research of high quality was being conducted in the home economics departments of the land-grant colleges, but with no Federal support.

In other words, in the program of agricultural research financed by Federal funds but little recognition was given to the farm home as an integral and important factor in the agricultural development of the country. The existence of such a situation and the need for correcting it were tacitly recognized in the wording of the Purnell Act which specified that the funds were to be used for paying "the necessary expenses of conducting investigations or making experiments bearing directly on the production, manufacture, preparation, use, distribution, and marketing of agricultural products and including such scientific researches as have for their purpose the establishment and maintenance of a permanent and efficient agricultural industry, and such economic and sociological investigations as have for their purpose the development and improvement of the rural home and rural life."

A definite impetus toward directing a considerable share of the new appropriations to research in various branches of home economics was given at the St. Louis conference, on policies and plans under the Purnell Act, of representatives of the Association of Land-Grant Colleges and Universities and the Department of Agriculture in April, 1925.[9] The Secretary of Agriculture in his address before the conference emphasized the fact that for the first time ample authority had been given for carrying on investigations in home economics, and, in recommending the enlargement of cooperative relations among the stations and with the department, expressed the opinion that this would be particularly desirable in the relatively new fields of agricultural economics, rural sociology, and home economics. This was recognized in the selection of projects for cooperative research, for of the six adopted two, the vitamin content of foods in relation to human nutrition and rural home management studies, fall quite definitely within the scope of home economics research.

As chairmen of the special committees to formulate plans and procedure for these projects, two home economics leaders were appointed—Louise Stanley, chief of the Bureau of Home Economics of the Department of Agriculture, for the vitamin project, and Anna E. Richardson, dean of the home economics division of Iowa State College, for the rural home management studies. A third project selected for national cooperation, a study of the factors which influence the quality and palatability of meat, is well suited to cooperation between the departments of animal husbandry and home economics, and representatives of home economics departments are serving on the committee in charge of this project.

ORGANIZATION AND ADMINISTRATION OF HOME ECONOMICS RESEARCH

At the institutions in which the home economics department is at-

[8] Smith, S. L. present status of home economics research at the agricultural experiment stations. *In* United States Department of Agriculture, Office of Experiment Stations, Work and expenditures of the Agricultural Experiment Stations, 1924, pp. 33–42. 1926.

[9] Allen, E. W., et al. report on the agricultural experiment stations, 1925, p. 3. Washington, D. C. 1926.

tached to the same administrative division as the experiment station, the machinery already existed for including home economics in the research program of the station, and it was at these institutions that the work was organized with the least delay. At others, arrangement had to be made on the basis of cooperation between the station and the separate home economics department of the college or university, with the understanding that the work was to be done under the supervision of the director of the experiment station. In still other instances it became necessary to organize within the station a new department of home economics research, a task requiring time, thought, and a considerable outlay of funds for equipment. Another cause of delay in the organization of this new work was the unprecedented demand for trained research workers in this field. The problem of supply and demand played no small part in the decision as to whether or not research in home economics should be attempted at once, in the selection of the type of research to be undertaken, and in the appraisal of the quality of the work already started. In appraising the accomplishments of the first year of research in home economics under the Purnell Act these points should be kept in mind.

SCOPE OF THE RESEARCH PROGRAM

The scope of the research program in home economics is indicated by the following list of all projects which were definitely approved by the Office of Experiment Stations up to and including November 1, 1926. Since comparatively few projects were approved before November 1, 1925, the tabulation is practically a record of the projects organized during the first year of administration of the Purnell fund.

In preparing this tabulation it seemed best not to limit it to projects conducted solely by home economics departments, but to include all Purnell projects which seemed to have a bearing upon home problems. In one or two instances projects are being conducted jointly by the home economics department and some other department at the station. In others the home economics department organizes and conducts the research, but has the cooperation of some other department in furnishing the material for the work. Such cooperation and participation in the various national cooperative projects, have been indicated in the tabulation.

TABLE 3.—*Purnell projects applying to home economics, 1925–26*

Station	Station department conducting the research	Other departments or stations cooperating[1]	Title of project
Alabama	Home economics	N. C. P. 3	A quantitative determination of the vitamin content of collards and of turnip tops, and the destruction of the vitamin by heat and oxidation.
Do	do	Animal nutrition	A study of the relative quality of soft pork and hard pork and their products.
Do	Animal industry		Effect of minerals on growth, reproduction, and ash content of white rats.
Do	do	N. C. P. 3	Factors affecting the vitamin B content of plant products.
Arizona	Home economics		Baking projects with Arizona wheats beginning with strains of Early Baart wheat.
Arkansas	Agricultural engineering and home economics.	N. C. P. 4, III	Basic factors in farm home planning.
California	Anatomy		Relation of fertility to nutrition in the Mammalia.
Colorado	Home economics		Baking flour mixtures at high altitudes.
Florida	do	N. C. P. 3	Determination of whether chlorophyll, chlorophyll alpha and beta, and the petroleum-ether extracts of the yellow pigments of alfalfa can be used as a source of vitamin A in animal nutrition.

[1] Cooperation with other departments within the station is designated by the name of the department and participation in the national cooperative projects as follows:

N. C. P. 3 The vitamin content of food in relation to human nutrition.
N. C. P. 4—Rural home management studies:
I, Food consumption and expenditures of farm families.
II. Present use of time by farm home makers.
III. Efficiency studies of the household plant.
IV. Standards of living and expenditures of farm families.
N. C. P. 6—Factors which influence the quality and palatability of meat.

TABLE 3.—*Purnell projects applying to home economics, 1925–26*—Continued

Station	Station department conducting the research	Other departments or stations cooperating	Title of project
Florida	Home economics		A study to determine the apparent prevalence of nutritional diseases in rural school children between the ages of 6 and 12 years in five representative counties in Florida.
Do	do		Determination and identification of the organisms which cause spoilage of canned vegetables in the South.
Do	do		Study of the factors affecting the jellying of kumquats, loquats, roselle, and guava.
Georgia	do	N. C. P. 4, I	Food habits of Georgia rural people.
Do	do	N. C. P. 3	Vitamin content of turnip greens, collards, peaches, and cantaloupes.
Do	Horticulture		Utilization of surplus fruits and vegetables and their by-products.
Idaho	Home economics	N. C. P. 4, II	Present use of time by home makers.[2]
Do	do	N. C. P. 4, I	Food consumption and food expenditures of farm families in relation to standards of requirement and income.
Illinois	do	N. C. P. 3	The distribution of vitamin B in the kernels of unmilled cereal grains.
Do	do	do	The effect of milling processes on the vitamin B content of cereal products used for human food.
Iowa	do	N. C. P. 4, III. Agricultural and electrical engineering.	The application of electricity in the farm home.
Do	do	N. C. P. 3. Vegetable crops.	The vitamin content of vegetables as affected by cultural methods and degree of maturity (tomatoes to be studied first).
Do	do	N. C. P. 3. Vegetable crops.	The vitamin content of vegetables as affected by storage (squash and carrots to be studied first).
Do	do	N. C. P. 3. Apiary	The vitamin content of honeys as affected by their preparation for the market.
Do	do	Animal husbandry.	Nutrition studies with meats to determine the effects on bodily vigor, reproduction, and lactation of feeding a high level of meat in the diet.
Do	do	Chemistry and horticulture.	The mineral content of vegetables as affected by the method of cooking.
Do	do	N. C. P. 6. Animal husbandry.	Factors influencing the quality and palatability of meat. A study of the influence of age and sex on the quality and palatability of beef. Subproject. A study of the quality and palatability of beef after cooking.
Do	do	N. C. P. 4, IV	Study of consumption habits of Iowa farm families.
Kansas	do	N. C. P. 4, II	Time study of infant care.[3]
Do	do		Utilization of calcium and phosphorus from fresh, dried, and evaporated milk.
Do	do		The vitamin content of the diet in relation to human nutrition: 1. Factors affecting seasonal variation in the growth curve of children.
Do	do	N. C. P. 3	2. Vitamin content of cabbage, sauerkraut, relishes, celery cabbage, cherries, peaches, rhubarb, and string beans.
Do	do	Physics	Protective value of certain clothing fabrics.
Do	do	N. C. P. 6. Animal husbandry and chemistry.	Influence of feed on cooking quality of meat of grass fat cattle (tenderness and color of cooked beef from grass fat steers and similar animals).
Kentucky	do	N. C. P. 3	An investigation of the vitamins of kale.
Do	do		An investigation of the metabolism of obesity.
Do	do	N. C. P. 3	The vitamins of mustard greens.
Louisiana	Chemistry	do	A study of the vitamin B content of mustard and turnip greens, collards, and lettuce.[4]
Maryland	Home economics		Housing in relation to farm labor turnover.
Massachusetts	do		Food consumption of school children in relation to health.
Do	Horticulture		Extraction of fruit juices in manufacture of fruit jellies.
Do	do		Manufacture and preservation of cranberry products.
Michigan	Home economics	N. C. P. 3	The vitamin content of some commercially canned vegetables (starting with peas).
Do	do	N. C. P. 3. Horticulture.	The vitamin A and B content of certain blanched and unblanched vegetables (start with lettuce).

[2] Completed July 2, 1926. [3] Completed. [4] Discontinued July 1, 1926.

TABLE 3.—*Purnell projects applying to home economics, 1925–26*—Continued

Station	Station department conducting the research	Other departments or stations cooperating	Title of project
Michigan	Home economics		Effect of the antirachitic factor and ultraviolet irradiation on calcium metabolism of women.
Do	Rural sociology		Environmental factors affecting the rural home.
Minnesota	Home economics		The influence of the vitamins on the utilization of iron and other compounds from food materials for blood formation and regeneration.
Do	do	N. C. P. 4, IV. Farm management.	A quantitative and qualitative study of farm homes in Minnesota with special emphasis on the influence of the farm upon the management of the home and the life of the family.
Do	do	N. C. P. 6. Animal husbandry.	A study of methods of preparing pork products.
Do	Rural sociology		A preliminary study of rural living in Minnesota.
Mississippi	Home economics	N. C. P. 4, I	A study of the food habits of people in two contrasting areas in Mississippi.
Do	do	do	Food consumption and expenditures for food of negro tenants in the Yazoo-Mississippi Delta.
Missouri	do		Use of various forms of yeast and various processes in making bread from Missouri soft wheat flour.[5]
Do	do	N. C. P. 6	A study of effect of temperature and time of cooking on quality and palatability of meat.
Do	do	N. C. P. 3	Influence of method of handling foods on their vitamin content. (1) The vitamin content of home-cooked, home-canned, and commercially canned foods. (2) Physical and chemical properties of plant juices possessing anti-scorbutic properties and of those having lost their potency as a result of methods of handling.
Do	Agricultural chemistry and animal husbandry.		The relation of diet to bodily activity and to capacity to withstand unfavorable circumstances.
Montana	Home economics		Standards of living in Montana public school dormitories.[6]
Do	do		Food preservation: I, vegetables.
Do	do	N. C. P. 3	The vitamin content of vegetables in winter storage (beginning with cabbage).
Nebraska	do	N. C. P. 4, III	Water carried for household purposes.
Do	do	do	Lighting with portable lamps.
Do	do	N. C. P. 4, II	Routine and seasonal work of the housekeeper.
Do	do	N. C. P. 4, III	Kerosene cooking stoves.
Do	do	do	The Nebraska rural kitchen.
Do	Rural economics		Costs and standards of living on Nebraska farms.
New Hampshire	Home economics	Nutrition Laboratory of Carnegie Institution.	Studies in human nutrition.—Caloric values of foods.
New Jersey	Chemistry	N. C. P. 3	Influence of soil composition and treatment on vitamin content of food plants.
Do	do		Influence of soil composition and treatment on the ash content of food plants.
New York (Cornell).	Home economics	N. C. P. 4, I	Food consumption of farm and village families. A study in consumers' demand.
Do	do	do	Index numbers of money cost of living in small towns and on farms in New York State.
Do	do	N. C. P. 3. Poultry	The antirachitic value of egg yolk and the effect of the food of the hen and other conditions on this factor in the yolk.
Do	do	N. C. P. 3. Vegetable gardening.	Determination of the relative vitamin content of certain foods and the changes which take place in the process of preparation: (1) carrots, (2) tomatoes.
North Carolina	do	N. C. P. 4, I	Kind and source of food consumed by North Carolina farm families.[7]
Do	Rural economics	N. C. P. 4, IV	A study of the standard of living in Wake County, N. C.
North Dakota	Animal industry and home economics.	N. C. P. 6	Factors influencing the quality and palatability of meat. Methods of cooking meats.
Ohio	Home economics		The effect of the use of salt in cooking vegetables.[8]

[5] Completed June 22, 1926.
[6] Discontinued June 1, 1926.
[7] Completed July 30, 1926.
[8] Completed Oct. 5, 1926.

TABLE 3.—*Purnell projects applying to home economics, 1925–26*—Continued

Station	Station department conducting the research	Other departments or stations cooperating	Title of project
Ohio	Home economics		Phosphorus intake of the preschool child, as shown by a dietary study made by the individual method.[8]
Do	Home economics and rural economics.	N. C. P. 4, IV	A study of the cost of family living on Ohio farms.
Do	Home economics		The basal metabolism of young women.
Do	Agronomy		The milling and baking qualities of Ohio wheats.
Oklahoma	Home economics	Rural life	The farm woman's part in establishing the economic status of the family by her standard of management, with special reference to clothing.
Do	Chemistry	N. C. P. 3	Relation of wave length to synthesis of plant vitamins and comparison of rate of vitamin synthesis and photosynthesis and of vitamin content and chlorophyll content.
Oregon	Home economics	N. C. P. 4, II	Present use of time by farm home makers.
Rhode Island	do	do	Use of time by rural home makers.
Do	Chemistry		Analytical investigation of the nutrient content of common vegetables.
South Carolina	Home economics	do	Leisure and how used by farm families in South Carolina.
South Dakota	do		Kind and quality of material in women's coats from typical retail stores of the State.
Do	do	N. C. P. 3	Study of the vitamin C content of vegetables canned in the pressure cooker (Swiss chard, spinach, and asparagus to be tested first).
Do	do	N. C. P. 4, III	Use of labor-saving devices in the preparation of meals.
Tennessee	Chemistry		Garlic odor and flavor in milk.
Do	do		The nature, origin, and function of "bios."
Texas	Agricultural chemistry.	N. C. P. 3	Variations in vitamin content of Texas food (corn meal, sweet potatoes, grapefruit, honey).
Utah	Home economics		Factors affecting penetration of ultra-violet rays of the sun through animal and vegetable fiber.
Do	do	N. C. P. 4, I	Food habits of Utah families.
Vermont	do	N. C. P. 4, IV	Study of methods of household budgeting and accounting.
Do	Animal industry		Nutritive value of milks.
Virginia	Home economics	N. C. P. 4, I	An investigation of food expenditures and dietary standards of rural families in Virginia.
Do	do		The relation of housing to the health of the family in rural homes.
Washington	do	N. C. P. 4, II	A study of the present use of time by farm homemakers in the State of Washington.
West Virginia	do	Horticulture Extension.	An investigation for developing methods for the economic utilization of surplus food products, with special reference to the problems of the home. Standardization of cherry preserves.
Wisconsin	do	N. C. P. 3. Horticulture.	The antiscorbutic content of tomatoes from different sources and produced under different conditions.
Do	do	N. C. P. 4, I	Studies of food expenditures of farm families in Wisconsin.
Do	Agricultural bacteriology and chemistry		Improving the quality of sauerkraut.
Wyoming	Home economics		Baking qualities and methods of baking Wyoming flour.
Do	do	N. C. P. 4, I	A study of food expenditures and consumption of farm families.

[8] Completed Oct. 5, 1926.

The tabulated list includes a total of 105 projects from 41 States. In 36 stations, as compared with 4 before the Purnell funds became available, home economics departments are conducting a total of 82 projects. In 4 additional stations it seemed advisable, for the first year at least, to allocate funds for research in foods and human nutrition to the chemistry department rather than to set up a division of home economics research or arrange for cooperation with the home economics department at the State

college or university. These stations contribute a total of 6 projects. The remaining 16 projects from 14 States, including 1 State not in the above classification, were not undertaken for the purpose of making a direct contribution to home economics, but may be expected to yield results of interest and application to various branches of this field. Undoubtedly many more projects, particularly those dealing with problems of rural sociology, might be included as satisfying this criterion. Of the small number of 7 States not listed as contributing Purnell projects of application to home economics, 1 was inaugurating research in home management and another was in search of a research worker at the time of writing. The misgivings of those who feared that home economics research would receive scanty support at the stations if a definite allocation of funds were not written into the act should be allayed by the generous support given this new work from the beginning.

CLASSIFICATION OF PROJECTS

Classifying the projects under the three main divisions of food and nutrition, rural home management studies (including food expenditure and consumption), and clothing and textiles, one finds, as was to be expected, food and nutrition leading with a total of 65 projects. Rural home management follows, with 37 projects, and the new and almost unexplored field of textile and clothing research contributes 3 projects.

Of the 65 projects in food and nutrition, 24 in 17 States come under the head of project 3 of the national cooperative projects, the vitamin content of foods in relation to human nutrition, and 5 under project 6, factors which influence the quality and palatability of meat. Project 4, rural home management studies, claims 29 of the 37 projects in this field. Of these, 10 are classified under subproject I (see footnote, p. 90), 7 under subproject II, 7 under subproject III, and 5 under subproject IV. The formulation of these various projects in rural home management was doubtless the incentive to the undertaking of this comparatively new type of research at so many places. In this perhaps more than in any other subject cooperation with other stations and with the Bureau of Home Economics of the Department of Agriculture, which is doing intensive work in this field,[10] is not only advisable but almost imperative.

Not only have the stations participated in the national cooperative projects but there has been evidence also of friendly cooperation within the stations. No less than 11 station departments are listed as cooperating in one or more projects conducted by the home economics departments, and the list of other departments conducting research of application to home economics numbers almost as many. Of these the chemistry departments contribute the largest number of projects, 10, chiefly vitamin studies. In this connection it is interesting to note that in the selection of research workers several of the home economics departments have recognized that the best training for certain types of research in home economics at the present time is to be found in the basic sciences, and have made their appointments from among those whose training has been in economics, biological chemistry, etc., rather than home economics. The ideal qualifications would of course include both the fundamental sciences and home economics.

PROGRESS AND RESULTS

Of the total of 105 projects listed only 8 are reported as having been discontinued or completed before November 1, 1926. This is a good indication that undue haste has not been made in the selection or development of projects. In the majority of cases the work had not reached a point at the end of the first year at which a satisfactory progress report could be made. For much of the nutrition work laboratories had to be organized and experimental colonies of rats and guinea pigs established. The rural home management studies, involving the collection of a large amount of data over a considerable period of time, have gone no further in most instances than the collection of the data for subsequent analysis.

At the institutions in which the research is being conducted by members of the regular staff of the home economics department on the usual academic schedule, the research was unavoidably curtailed by the intervention of the summer vacation. Vitamin studies in particular were seriously affected by the necessity of bringing the

[10] STANLEY, L. REPORT OF THE CHIEF OF THE BUREAU OF HOME ECONOMICS, p. 5. Washington, D. C. 1926.

work to an end in June and starting almost from the beginning in September. This situation is one that will doubtless be remedied by arrangements for a continuation of work.

The few progress reports available in the nutrition studies have been noted briefly on pages 70, 72 under wheat flour and bread, vitamin studies, and the removal of garlic odor and flavor from milk. The discovery of a simple and practical means of removing the offensive garlic odor and flavor from milk is considered by the director of the Tennessee station, at which the work was done, to be the outstanding contribution from the station during the past year.

Work on the protective value of certain clothing fabrics at the Kansas station has progressed to such a point that conclusions have been drawn of particular interest at the present time, when the beneficial effects of unadulterated sunlight are so widely heralded. This project had for its original purpose a study of the relative degree of protection afforded the skin against sunburn by different textile fabrics to determine whether the differences noted were due to the nature of the protective covering or to the construction of the fabric. White fabrics were selected of silk, linen, cotton, and wool of plain weave matching as closely as possible. The screening effect of the different fabrics was determined by the action of direct sunlight on the skin covered with the fabric and also by the action of ultraviolet light on sensitized paper covered with the fabric, by photometric measurements, and by spectograph analysis.

The data thus far obtained show that the protection from sunburn afforded the skin by different fabrics depends, first and foremost, upon the percentage of interspace due to weave; and, second, upon the nature of the fabric. The vegetable fibers, cotton and linen, however, had a small coefficient of protection on account of the fact that they transmit some of the rays that burn, while the animal fabrics, silk and wool, had a greater protective action on account of absorbing a portion of the rays. Further development of this project should be awaited with interest. The physics department of the college is actively cooperating with the textile division of the home economics department in this and other textile projects. Interesting and ingenious apparatus has been devised or adapted from other purposes for testing the relative heat absorption of different fabrics, and the wearing quality, particularly as affected by rubbing. It is to be hoped that as time goes on more will be attracted to this undeveloped field of textile research.

Another project illustrating a comparatively new type of work, and one which lends itself to cooperation with other departments is the Iowa project covering the application of electricity in the farm home. For this, 12 homes in a rural district provided with high-power electricity were selected and a preliminary survey was made of these homes to find out what electrical equipment was already in use and what would be the next piece purchased when possible to do so. On the basis of this survey pieces of equipment were installed in the different homes, each being separately metered and provided with a recording device showing automatically when the equipment is used and the load of electricity carried during its use.

From the records which will be available after the equipment has been in operation for some time it is hoped that definite recommendations can be made as to what type of electrical equipment for the home can be used advantageously with the farm equipment already in use to make the load more uniform and lower the cost of operating. The homes are visited frequently and when any problem arises requiring investigation this is transferred to the laboratories and studied there. A preliminary study of the size of transformers to use in the homes was conducted by the engineering department and this department also installed the equipment and is cooperating in many ways. Thus far more work has been done in a comparative way with electrical ranges than with any other type of equipment.

These are by no means the only projects worthy of special notice, but have been selected as illustrating new fields of research promising interesting results and as emphasizing the value of the cooperation of other departments with the home economics department in which research is in its infancy.

OUTLOOK

Judging by the number of stations in which work in home economics has been organized, the number and type of projects adopted, and the prelimi-

nary reports of progress made, there is ample ground for gratification and encouragement to those who are particularly interested in the development of research in this field. The new work has been given recognition and generous support as an integral part of the research program of many of the stations. Substantial progress has already been made and a sound foundation has been laid for future development.

PUBLICATIONS OF THE STATIONS (1925–26)

The following is a list of regular publications of the stations received by the office during the year ended June 30, 1926. It includes 752 publications, classified as follows: Meteorology, 13; soils—fertilizers, 55; botany—plant nutrition, 10; genetics, 21; field crops, 80; horticulture, 72; forestry, 1; plant diseases, 59; entomology and zoology, 67; foods and human nutrition, 22; animal production, 72; dairying, 34; diseases of livestock, 30; agricultural engineering, 30; economics and sociology, 56; and reports, periodicals, regulatory and miscellaneous publications, 130.

The stations contributed or collaborated in 65 articles for the Journal of Agricultural Research. They also published an increased number of articles, reporting or based upon their work, in outside scientific and technical journals.

METEOROLOGY

Meteorological observations at the Massachusetts Agricultural Experiment Station. J. E. Ostrander et al. Mass. Sta. Met. Buls. 438–449, 4 p. each. 1925–1926.

The climate of New York State. R. A. Mordorf. N. Y. Cornell Sta. Bul. 444, 38 p., illus. 1925.

SOILS—FERTILIZERS

Physiological aspects of soil solution investigations. D. R. Hoagland. Hilgardia [Calif. Sta.], vol. 1, no. 11, p. 227–257. 1925.

The effect of a paper mulch on soil temperature. C. F. Shaw. Hilgardia [Calif. Sta.], vol. 1, no. 15, p. 341–364, illus. 1926.

Adsorption by activated sugar charcoal, with particular reference to adsorption and soil acidity. E. J. Miller. Mich. Sta. Tech. Bul. 73, 60 p. 1925.

Effect of cultivation on moisture and nitrate content of field soil. W. H. Sachs. Ark. Sta. Bul. 205, 22 p., illus. 1926.

The nitrate question in Colorado.—A review for the farmer. W. P. Headden. Colo. Sta. Bul. 299, 27 p. 1925.

An explanation for the relative effects of timothy and clover residues in the soil on nitrate depression. B. D. Wilson and J. K. Wilson. N. Y. Cornell Sta. Mem. 95, 21 p. 1925.

Alkali soils—origin, examination, and management. P. L. Hibbard. Calif. Sta. Circ. 292, 14 p. 1925.

The reaction between calcium sulphate and sodium carbonate, and its relation to the reclamation of black alkali lands. J. F. Breazeale and P. S. Burgess. Ariz. Sta. Tech. Bul. 6, p. 125–139. 1926.

Effects of forest fires on land clearing and crop production. M. J. Thompson. Minn. Sta. Bul. 220, 23 p., illus. 1925.

Soil flora studies.—VI, The punctiform-colony-forming bacteria in soil. H. J. Conn. N. Y. State Sta. Tech. Bul. 115, 26 p. 1925.

The Illinois system of permanent soil fertility in the light of twenty-five years of investigation. L. H. Smith. Ill. Sta. Circ. 298, 12 p., illus. 1925.

What the Illinois farmer can do to learn about his soils. E. E. DeTurk. Ill. Sta. Circ. 302, 8 p., illus. 1925.

A general purpose soil auger and its use on the farm. S. W. Cosby. Calif. Sta. Circ. 306, 4 p., illus. 1926.

Mercer County soils. R. S. Smith, E. E. DeTurk, F. C. Bauer, and L. H. Smith. Ill. Sta. Soil Rpt. 29, 64 p., illus. 1925.

Johnson County soils. R. S. Smith, E. A. Norton, E. E. DeTurk, F. C. Bauer, and L. H. Smith. Ill. Sta. Soil Rpt. 30, 46 p., illus. 1925.

Rock Island County soils. R. S. Smith, O. I. Ellis, E. E. DeTurk, F. C. Bauer, and L. H. Smith. Ill. Sta. Soil Rpt. 31, 66 p., illus. 1925.

Randolph County soils. R. S. Smith, E. E. DeTurk, F. C. Bauer, and L. H. Smith. Ill. Sta. Soil Rpt. 32, 64 p., illus. 1925.

A study of the secondary effects of hill fertilization. H. J. Harper. Iowa Sta. Research Bul. 87, p. 221–251, illus. 1925.

Soil survey of Iowa—Emmet County soils. W. H. Stevenson, P. E. Brown, et al. Iowa Sta. Soil Survey Rpt. 36, 72 p., illus. 1924.

Soil survey of Iowa—Dickinson County soils. W. H. Stevenson, P. E. Brown, et al. Iowa Sta. Soil Survey Rpt. 37, 72 p., illus. 1924.

Soil survey of Iowa.—Hardin County soils. W. H. Stevenson, P. E. Brown, et al. Iowa Sta. Soil Survey Rpt. 38, 79 p., illus. 1925.

Soil survey of Iowa.—Dallas County soils. W. H. Stevenson, P. E. Brown, et al. Iowa Sta. Soil Survey Rpt. 39, 79 p., illus. 1926.

Fertilizer suggestions for Barry County soils. M. M. McCool and J. O. Veatch. Mich. Sta. Circ. 71, 8 p., illus. 1925.

Fertilizer suggestions for Berrien County soils. M. M. McCool and J. O. Veatch. Mich. Sta. Circ. 72, 8 p., illus. 1925.

Fertilizer suggestions for Cass County soils. M. M. McCool and J. O. Veatch. Mich. Sta. Circ. 73, 8 p., illus. 1925.

Fertilizer suggestions for Hillsdale County soils. M. M. McCool and J. O. Veatch. Mich. Sta. Circ. 74, 8 p., illus. 1925.

Fertilizer suggestions for Ingham County soils. M. M. McCool and J. O. Veatch. Mich. Sta. Circ. 75, 8 p., illus. 1925.

Fertilizer suggestions for Isabella County soils. M. M. McCool and J. O. Veatch. Mich. Sta. Circ. 76, 8 p., illus. 1925.

Fertilizer suggestions for Kalamazoo County soils. M. M. McCool and J. O. Veatch. Mich. Sta. Circ. 77, 8 p., illus. 1925.

Fertilizer suggestions for Livingston County soils. M. M. McCool and J. O. Veatch. Mich. Sta. Circ. 78, 8 p., illus. 1925.

Fertilizer suggestions for Macomb County soils. M. M. McCool and J. O. Veatch. Mich. Sta. Circ. 79, 8 p., illus. 1925.

Fertilizer suggestions for Muskegon County soils. M. M. McCool and J. O. Veatch. Mich. Sta. Circ. 80, 8 p., illus. 1925.

Fertilizer suggestions for Ottawa County soils. M. M. McCool and J. O. Veatch. Mich. Sta. Circ. 81, 8 p., illus. 1925.

Fertilizer suggestions for St. Joseph County soils. M. M. McCool and J. O. Veatch. Mich. Sta. Circ. 82, 8 p., illus. 1925.

Fertilizer suggestions for Van Buren County soils. M. M. McCool and J. O. Veatch. Mich. Sta. Circ. 83, 8 p., illus. 1925.

Fertilizer suggestions for Calhoun County soils. M. M. McCool and J. O. Veatch. Mich. Sta. Circ. 88, 8 p., illus. 1925.

The brown loess soils of Missouri and their utilization. H. H. Krusekopf. Mo. Sta. Bul. 235, 55 p., illus. 1925.

The soils experiment fields of Missouri. (A summary prepared for the use of farmers, teachers, and extension workers.) F. L. Duley and M. F. Miller. Mo. Sta. Bul. 238, 60 p., illus. 1926.

Soils of Daniels County. Soil reconnaissance of Montana, preliminary report. L. F. Gieseker. Mont. Sta. Bul. 174, 32 p., illus. 1925.

Soils of Roosevelt County. Soil reconnaissance of Montana, preliminary report. L. F. Gieseker. Mont. Sta. Bul. 179, 46 p., illus. 1925.

Soil survey of Miami County, Ohio. E. R. Allen and O. Gossard. Ohio Sta. Soil Survey Rpt. No. 1, 90 p., illus. 1924.

Soils of Eastland, El Paso, Lubbock, and San Saba Counties. G. S. Fraps. Tex. Sta. Bul. 337, 47 p., illus. 1926.

The ecenomic value of farm manure as a fertilizer on Iowa soils. W. H. Stevenson, P. E. Brown, L. W. Forman, W. G. Baker, J. L. Boatman, and B. Boatman. Iowa Sta. Bul. 236, p. 219–245, illus. 1926.

The substitution of stable manure by fertilizers, green manures, and peat, II. B. L. Hartwell and F. K. Crandall. R. I. Sta. Bul. 201, 16 p. 1925.

The effect of straw on plant growth. R. C. Collison and H. J. Conn. N. Y. State Sta. Tech. Bul. 114, 35 p., illus. 1925.

The use of concentrated fertilizers. A. B. Beaumont. Mass. Sta. Circ. 72, 4 p. 1925.

Testing fertilizers for Missouri farmers, 1925. L. D. Haigh. Mo. Sta. Bul. 239, 71 p., illus. 1926.

Fertilizers for special crops. C. J. Chapman and A. R. Whitson. Wis Sta. Bul. 383, 30 p., illus. 1926.

Fertilizer experiments.—Methods of application and effect on germination, early growth, hardiness, root growth, lodging, maturity, quality and yield. E. Truog, H. J. Harper, O. C. Magistad, F. W. Parker, and J. Sykora. Wis. Sta. Research Bul. 65, 56 p., illus. 1925.

Nitrogen availability studies on crops harvested at different stages of growth. G. H. Singleton. N. J. Stas. Bul. 431, 28 p., illus. 1925.

Profits from phosphates. A. R. Whitson and G. Richards. Wis. Sta. Bul. 376, 22 p., illus. 1925.

Liming the soil. P. L. Hibbard. Calif. Sta. Circ. 305, 15 p. 1926.

More lime needed for New Jersey farms. A. W. Blair. N. J. Stas. Bul. 430, 23 p., illus. 1926.

Field experiments with gypsum in Iowa. L. W. Erdman and W. B. Bollen. Iowa Sta. Bul. 232, p. 97–119. 1925.

The influence of sulphur and gypsum upon the composition and yield of legumes. J. R. Neller. Wash. Col. Sta. Bul. 190, 47 p., illus. 1925.

BOTANY—PLANT NUTRITION

Senescence and rejuvenescence in the cells of the potato plant. B. F. Lutman. Vt. Sta. Bul. 252, 78 p., illus. 1925.

Phloridzin.—I, The significance of phloridzin in apple and pear tissue. II, The hydrolysis and estimation of phloridzin. E. M. Harvey. Oreg. Sta. Bul. 215, 23 p., illus. 1925.

A study of respiration in potatoes with special reference to storage and transportation. W. D. Kimbrough. Md. Sta. Bul. 276, p. 51–72, illus. 1925.

The relation of stored food to cambial activity in the apple. E. L. Proebsting. Hilgardia [Calif. Sta.], vol. 1, No. 5, p. 81–106, illus. 1925.

Some chemical constituents of fruit spurs associated with blossom bud formation in the Baldwin apple. H. R. Kraybill, G. F. Potter, S. W. Wentworth, P. T. Blood, and J. T. Sullivan. N. H. Sta. Tech. Bul. 29, 41+XIII p., illus. 1925.

Factors governing the initiation of sprout growth in citrus shoots. P. F. Halma. Hilgardia [Calif. Sta.], vol. 1, no. 14, p 295–340, illus. 1926.

Effect of nutrient conditions on colloidal properties of certain vegetable crops. J. W. Crist. Mich. Sta. Tech. Bul. 74, 27 p., illus. 1926.

How to know the mushrooms and toadstools. F. C. Stewart. N. Y. State Sta. Circ. 82, 11 p. 1925.

Studies on the Coccaceae.—VI, The agglutination reaction as a test for differentiating the micrococci. G. J. Hucker. VII, The serological relationships of strains of micrococci isolated from similar habitats. G. J. Hucker and A. H. Robertson. N. Y. State Sta. Tech. Bul. 118, 28 p. 1926.

The flora of the Cayuga Lake Basin, New York.—Vascular plants. K. M. Wiegand and A. J. Eames. N. Y. Cornell Sta. Mem. 92, 491 p., illus. 1925.

GENETICS

The improvement of naturally cross-pollinated plants by selection in self-fertilized lines.—I, The production of inbred strains of corn. D. F. Jones and P. C. Mangelsdorf. Conn. State Sta. Bul. 266, p. 345–418, illus. 1925.

The development and inheritance of a defective endosperm in maize. B. L. Wade. W. Va. Sta. Bul. 197, 20 p., illus. 1925.

Biometrical studies of lint and seed characters in cotton. G. N. Stroman. Tex. Sta. Bul. 332, 20 p., illus. 1925.

Heritable chlorophyll deficiencies in seedling cotton. G. N. Stroman and C. H. Mahoney. Tex. Sta. Bul. 333, 22 p., illus. 1925.

Studies of inheritance of earliness in certain Avena crosses. C. F. Noll. Pa. Sta. Bul. 194, 43 p., illus. 1925.

Variations within and between morphological varieties of oats and barley. R. G. Wiggans. N. Y. Cornell Sta. Mem. 94, 35 p., illus. 1925.

Correlations between length of spike and culm in wheat and certain characters of progeny, including yield. A. N. Hume, E. W. Hardies, and C. Franzke. S. Dak. Sta. Bul. 214, 16 p., illus. 1925.

Secondary sex characters in *Asparagus officinalis* L. W. W. Robbins and H. A. Jones. Hilgardia [Calif. Sta.], vol. 1, no. 9, p. 183–202, illus. 1925.

Sex expression in spinach. J. T. Rosa. Hilgardia [Calif. Sta.], vol. 1, no. 12, p. 259–274, illus. 1925.

Control of soil heterogeneity and use of the probable error concept in plant breeding studies. H. K. Hayes. Minn. Sta. Tech. Bul. 30, 21 p. 1925.

Studies of inheritance and evolution in orthoptera.—V, The grouse locust *Apotettix eurycephalus* Hancock. R. K. Nabours. Kans. Sta. Tech. Bul. 17, 231 p., illus. 1925.

The inheritance of body-weight in poultry.—I, In the Cornish-Hamburgh cross. H. G. May. R. I. Sta. Bul. 200, 34 p., illus. 1925.

The standard deviation in the weight of White Leghorn eggs (technical). H. Atwood. W. Va. Sta. Bul. 195, 22 p. 1925.

The correlation between sexual maturity and egg production. H. L. Kempster. Mo. Sta. Research Bul. 78, 16 p., illus. 1925.

The inheritance of fertility and hatchability in poultry. F. A. Hays and R. Sanborn. Mass. Sta. Tech. Bul. 6, pop. ed., 4 p. 1924.

Broodiness in relation to fecundity in the domestic fowl. F. A. Hays and R. Sanborn. Mass. Sta. Tech. Bul. 7, p. 55–83, illus. 1926.

Studies in milk secretion.—XV, Guernsey sires' progeny performance for milk yield, butter-fat percentage, and butter-fat. J. W. Gowen. Me. Sta. Bul. 324, p. 35–124, illus. 1925.

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The costly influence of an inferior sire. C. C. Culbertson and J. M. Evvard. Iowa Sta. leaflet 1, 7 p. 1925.

Measuring the breeding value of dairy sires by the records of their first few advanced registry daughters. F. A. Davidson. Ill. Sta. Bul. 270, p. 545–566, illus. 1925.

A study of the breeding records of a group of Shorthorn cows. C. V. Wilson. W. Va. Sta. Bul. 198, 55 p., illus. 1925.

FIELD CROPS

Experiments relating to the time of cutting alfalfa. S. C. Salmon, C. O. Swanson, and C. W. McCampbell. Kans. Sta. Tech. Bul. 15, 50 p., illus. 1925.

Hardy alfalfa for Nebraska. T. A. Kiesselbach and A. Anderson. Nebr. Sta. Circ. 32, 8 p., illus. 1925.

Alfalfa field registration. H. L. Bolley and O. A. Stevens. N. Dak. Sta. Circ. 30, 8 p., illus. 1926.

Experiments with alfalfa in eastern Virginia. R. P. Cocke. Va. Sta. Bul. 247, 16 p., illus. 1926.

Colsess barley. D. W. Robertson and A. Keser. Colo. Sta. Bul. 303, 11 p., illus. 1925.

The mat bean (*Phaseolus aconitifolius*). P. B. Kennedy and B. A. Madson. Calif. Sta. Bul. 396, 33 p., illus. 1925.

Buckwheat in Michigan. C. E. Cormany. Mich. Sta. Spec. Bul. 151, 11 p., illus. 1926.

Berseem or Egyptian clover (*Trifolium alexandrinum*). A preliminary report. P. B. Kennedy and W. W. Mackie. Calif. Sta. Bul. 389, 32 p., illus. 1925.

Clover seed for Indiana farms. A. T. Wiancko. Ind. Sta. Circ. 131, 4 p., illus. 1926.

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Experiments with varying stands and distribution of corn.—Part I, Rates of planting corn. Part II, Checked versus drilled planting of corn. Part III, Wide and narrow rows of corn. Part IV, Conclusions. L. W. Osborn. Ark. Sta. Bul. 200, 36 p. 1925.

Crossed corn. D. F. Jones and P. C. Mangelsdorf. Conn. State Sta. Bul. 273, p. 149–187, illus. 1926.

Corn and soybeans as a combination crop for silage. W. L. Slate, jr., and B. A. Brown. Conn. Storrs Sta. Bul. 133, p. 351–376, illus. 1925.

Factors influencing lodging in corn. B. Koehler, G. H. Dungan, and J. R. Holbert. Ill. Sta. Bul. 266, p. 309–371, illus. 1925.

An experiment in selecting corn for yield by the method of the ear-row breeding plot. L. H. Smith and A. M. Brunson. Ill. Sta. Bul. 271, p. 565–583, illus. 1925.

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Composition and maturity of corn. T. H. Hopper. N. Dak. Sta. Bul. 192, 76 p., illus. 1925.

Cotton variety experiments. J. O. Ware. Ark. Sta. Bul. 197, 27 p. 1925.

Cotton fertilizer experiments 1921–25, Delta Branch Station. W. E. Ayres. Miss. Sta. Bul. 234, 16 p., illus. 1926.

Report on Missouri cotton experiment fields, 1925. B. M. King. Mo. Sta. Circ. 141, 7 p., illus. 1926.

Studies on treatment of cotton seed. S. G. Lehman. N. C. Sta. Tech. Bul. 26, 71 p., illus. 1925.

Cotton experiments at Florence. E. E. Hall and G. M. Armstrong. S. C. Sta. Bul. 225, 31 p., illus. 1926.

Flax in Montana. C. McKee. Mont. Sta. Circ. 132, 15 p., illus. 1926.

Flax facts. T. Stoa. N. Dak. Sta. Circ. 26, 8 p., illus. 1925.

Growing flax in South Dakota. A. N. Hume, E. W. Hardies, and C. Franzke. S. Dak. Sta. Bul. 213, 24 p., illus. 1925.

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Fertilizers for Irish potatoes. J. R. Cooper and C. W. Rapp. Ark. Sta. Bul. 206, 15 p., illus. 1926.

Potato production in California. J. T. Rosa. Calif. Sta. Circ. 287, 44 p., illus. 1925.

Miscellaneous experiments with potatoes. B. A. Brown and W. L. Slate, jr. Conn. Storrs Sta. Bul. 126, p. 27–42, illus. 1925.

Value of certified Irish potato seed in Mississippi. H. H. Wedgworth and C. B. Anders. Miss. Sta. Circ. 60, 4 p., illus. 1925.

Potatoes.—Certification for seed in North Dakota. H. L. Bolley and W. G. Couey. N. Dak. Sta. Circ. 31, 12 p., illus. 1926.

Potato production in Utah. G. Stewart, Utah Sta. Circ. 58. (Revision of Circ. 40.) 63 p., illus. 1925.

Winter rye in North Dakota. T. E. Stoa. N. Dak. Sta. Bul. 193, 14 p., illus. 1925.

Improving stands of grain sorghums by seed treatments. H. H. Finnell. Okla. Sta. Bul. 159, 15 p., illus. 1926.

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Soy beans in Connecticut. B. A. Brown and W. L. Slate, jr. Conn. Storrs Sta. Bul. 129, p. 255–287, illus. 1925.

Soy beans for Iowa. H. D. Hughes and F. S. Wilkins. Iowa Sta. Bul 228, abridged ed., 16 p., illus. 1925.

Soy beans—Production, composition, and feeding value. J. E. Metzger, M. G. Holmes, and H. Bierman. Md. Sta. Bul. 277, p. 73–101, illus. 1925.

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The quality of packet vegetable seed on sale in New York in 1924. M. T. Munn. N. Y. State Sta. Bul. 533, 27 p. 1925.
Agricultural seed inspection. A. S. Lutman. Vt. Sta. Bul. 253, 16 p. 1925.

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Report on commercial insecticides and fungicides, 1925. E. M. Bailey. Conn. State Sta. Bul. 272, p. 141–150+iv. 1925.
Analyses of materials sold as insecticides and fungicides during 1925. C. S. Cathcart and R. L. Willis. N. J. Stas. Bul. 424, 16 p. 1925.
The chemical composition of insecticides and fungicides (1924–1925 report). R. R. Robinson and W. W. Yates. Oreg. Sta. Circ. 64, 16 p. 1925.
Inspection of agricultural lime products. H. D. Haskins, L. S. Walker, and G. B. Dalrymple. Mass. Sta. Control Ser. Bul. 34, 6 p., illus. 1925.
Results of seed and legume inoculant inspection for 1925. J. G. Fiske. N. J. Stas. Bul. 428, 83 p., illus. 1926.
Biennial report of apiary inspection, 1923–1925. C. S. Rude. Tex. Sta. Circ. 38, 13 p., illus. 1925.
A history of Connecticut agriculture. E. H. Jenkins. Conn. State Sta. Reprint from History of Connecticut, p. 289–425.
Stallion enrollment.—XIV, Report of stallion enrollment work for the year 1925 with lists of stallions and jacks enrolled. Ind. Sta. Circ. 129, 47 p., illus. 1925.
These fifty years. R. P. Crawford. Nebr. Sta. Circ. 26, 175 p., illus. 1925.
What the station can do. R. W. Thatcher. N. Y. State Sta. Circ. 81, 7 p. 1925.
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Creamery inspection in New Jersey. (Sixth annual report.) G. I. Ball. N. J. Stas. Bul. 429, 15 p., illus. 1926.
Advanced registry testing. A. D. Burke and P. C. McGilliard. Okla. Sta. Circ. 61, 29 p., illus. 1926.
Rules and regulations for the second Utah intermountain egg-laying contest. B. Alder. Utah Sta. Circ. 55, 4 p., illus. 1925.
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PUBLICATION LISTS AND MISCELLANEOUS

Abstracts of papers not included in bulletins, finances, meteorology, index. Me. Sta. Bul. 321, 163+XII p. 1924.
List of available publications, July 1, 1925. Nebr. Sta. Circ. 27, 7 p.
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Notice announcing the issue of bulletins 244–253, inclusive. Vt. Sta. Circ. 13, 1 p. 1926.

INCOME, EXPENDITURES, AND OTHER STATISTICS, 1926

By J. I. Schulte

The following tables give detailed data regarding (1) personnel, publications, and mailing lists of the experiment stations; (2) revenues and additions to equipment; (3) expenditures from the Hatch, Adams, and Purnell funds; and (4) total disbursements from the United States Treasury under the Hatch, Adams, and Purnell Acts from their passage to the end of the fiscal year, June 30, 1926.

Table 4. *Personnel, publications, and mailing lists of experiment stations, 1926*

Station	Number on staff	Number of teachers on staff	Number on staff who assist in extension work	Publications during fiscal year 1925–26		Number of names on mailing list
				Number	Pages	
Alabama (College)	31	16	2	4	76	1,800
Alabama (Tuskegee)	5	4				
Alaska	7			2	87	3,000
Arizona	25	27	16	17	524	4,800
Arkansas	34	25		9	250	3,000
California	157	91	87	46	1,426	15,525
Colorado	63	28	14	19	475	800
Connecticut (State)	33			18	800	14,850
Connecticut (Storrs)	18	9	1	3	95	9,000
Delaware	20	8	3	4	147	7,000
Florida	52	1	3	31	564	25,000
Georgia	15	1	1	5	45	10,475
Guam	5			2	41	
Hawaii	6		3	2	48	1,500
Idaho	44	20	9	20	244	20,895
Illinois	127	76	30	275	1,825	23,571
Indiana	93	20		49	980	36,020
Iowa	92	40		33	788	28,131
Kansas	100	68		18	760	13,000
Kentucky	65	26	5	14	574	13,500
Louisiana	33	3	4	3	105	6,590
Maine	23	1		8	362	20,300
Maryland	50	25		43	300	16,000
Massachusetts	64	14		25	328	10,000
Michigan	101	41	4	46	10,204	42,000
Minnesota	138	127	3	22	892	20,000
Mississippi	41	12		11	124	15,000
Missouri (College)	67	60		83	1,327	5,800
Missouri (Fruit)	1					
Missouri (Poultry)	3					
Montana	47	16	6	15	360	6,000
Nebraska	45	19		15	545	7,228
Nevada	14			2	50	7,000
New Hampshire	33	18	10	8	240	7,500
New Jersey (State)	70	35	4	117	2,242	17,300
New Jersey (College)	40					
New Mexico	24	14	6	82	394	8,500
New York (State)	56			28	712	15,000
New York (Cornell)	93	56	8	21	1,463	4,472
North Carolina	44	14		5	232	11,780
North Dakota	48	15	2	14	384	10,000
Ohio	101	17		68	590	70,000
Oklahoma	43	34		9	222	18,000
Oregon	61	35		39	943	1,660
Pennsylvania	95	76	40	8	232	45,576
Pennsylvania (Nutrition)	9					
Porto Rico	8			1	29	3,000
Rhode Island	14	3		10	186	3,000
South Carolina	36	11	7	9	398	5,600
South Dakota	34	31	5	5	128	33,949
Tennessee	29	2		9	144	12,000
Texas	71			34	655	70,927
Utah	37	24	5	11	186	9,262
Vermont	23	9	1	7	300	7,300
Virginia	38	8	1	9	231	12,000
Virgin Islands	3			4	69	500
Washington	42	17		20	933	3,286
West Virginia	46	23	2	52	569	12,500
Wisconsin	84	81	66	20	743	53,984
Wyoming	26	10	1	9	198	8,000
Total	2,827	1,311	349	1,443	36,769	832,881

TABLE 5.—*Revenues and additions to*

Station	Federal			State	Balances [1] from previous year	Fees	Sales
	Hatch fund	Adams fund	Purnell fund				
Alabama	$15,000.00	$15,000.00	$20,000.00	$34,500.00	$14,586.98		$7,654.82
Alaska [2]							
Arizona	15,000.00	15,000.00	20,000.00	99,242.79	775.43		6,147.89
Arkansas	15,000.00	15,000.00	20,000.00	57,755.76			14,600.00
California	15,000.00	15,000.00	20,000.00	466,444.76	30,534.63	$12,807.78	101,422.23
Colorado	15,000.00	15,000.00	20,000.00	104,343.37	27,875.27		36,721.07
Connecticut (State)	7,500.00	7,500.00	10,000.00	167,697.10	157.38	19,000.00	
Connecticut (Storrs)	7,500.00	7,500.00	10,000.00	32,000.00	3,901.13		
Delaware	15,000.00	15,000.00	20,000.00	18,500.00	2,308.50		18,771.13
Florida	15,000.00	15,000.00	20,000.00	273,381.50	7,368.21		9,704.59
Georgia	15,000.00	15,000.00	20,000.00	8,800.00	347.52		8,017.38
Guam [2]							
Hawaii [2]							
Idaho	15,000.00	15,000.00	20,000.00	46,288.69	1,361.49		3,282.89
Illinois	15,000.00	15,000.00	20,000.00	380,254.94	17,962.39		57,006.17
Indiana	15,000.00	15,000.00	20,000.00	209,137.16	140,830.92	122,443.51	83,597.73
Iowa	15,000.00	15,000.00	20,000.00	265,000.00	9,630.14		35,463.24
Kansas	15,000.00	15,000.00	20,000.00	102,400.00	28,809.42	39,134.06	19,119.17
Kentucky	15,000.00	15,000.00	20,000.00	111,932.77	27,407.34	97,729.30	61,906.60
Louisiana	15,000.00	15,000.00	20,000.00	50,093.10	569.91	30,336.90	7,067.20
Maine	15,000.00	15,000.00	20,000.00	38,000.00		10,016.24	19,650.68
Maryland	15,000.00	15,000.00	20,000.00	80,221.42	709.28		16,825.86
Massachusetts	15,000.00	15,000.00	20,000.00	128,904.32		42,731.30	18,089.76
Michigan	15,000.00	15,000.00	20,000.00	288,000.00			36,052.68
Minnesota	15,000.00	15,000.00	20,000.00	221,504.39		99,311.46	83,460.64
Mississippi	15,000.00	15,000.00	20,000.00	103,479.57	17,043.46		12,921.78
Missouri	15,000.00	15,000.00	20,000.00	37,059.62	20,146.38	34,545.18	43,528.90
Montana	15,000.00	15,000.00	20,000.00	101,883.09		4,013.92	23,249.12
Nebraska	15,000.00	15,000.00	20,000.00	112,416.39			66,015.89
Nevada	15,000.00	15,000.00	20,000.00	3,043.89	937.04		4,007.61
New Hampshire	15,000.00	15,000.00	20,000.00	4,500.00	3,996.58		1,644.02
New Jersey (State)				106,483.89		61,892.02	37,223.66
New Jersey (College)	15,000.00	15,000.00	20,000.00				
New Mexico	15,000.00	15,000.00	20,000.00	7,500.00	20,291.72		10,000.00
New York (State)	1,500.00	1,500.00	2,000.00	285,025.00	8,678.07		10,860.42
New York (Cornell)	13,500.00	13,500.00	18,000.00	240,896.01			28,358.22
North Carolina	15,000.00	15,000.00	20,000.00	60,000.00			19,821.62
North Dakota	15,000.00	15,000.00	20,000.00	265,400.00	57,023.82		70,176.45
Ohio	15,000.00	15,000.00	20,000.00	710,200.00	120,591.25		57,221.47
Oklahoma	15,000.00	15,000.00	20,000.00	30,000.00	2,857.17		16,217.36
Oregon	15,000.00	15,000.00	20,000.00	117,000.00	37,771.38		45,139.73
Pennsylvania	15,000.00	15,000.00	20,000.00	73,934.97			3,136.89
Porto Rico [2]							
Rhode Island	15,000.00	15,000.00	20,000.00	1,393.02			5,175.20
South Carolina	15,000.00	15,000.00	20,000.00	72,255.01	1,805.21		42,363.27
South Dakota	15,000.00	15,000.00	20,000.00	57,920.00	11,670.94		17,207.22
Tennessee	15,000.00	15,000.00	20,000.00	37,351.03			18,197.73
Texas	15,000.00	15,000.00	20,000.00	270,048.82	15,650.18		101,457.76
Utah	15,000.00	15,000.00	20,000.00	60,223.62			22,319.24
Vermont	15,000.00	15,000.00	20,000.00		16,072.50		1,208.32
Virginia	15,000.00	15,000.00	20,000.00	72,588.36	10,983.08		8,557.30
Virgin Islands [2]							
Washington	15,000.00	15,000.00	20,000.00	111,222.06			49,390.75
West Virginia	15,000.00	15,000.00	20,000.00	96,500.00	3,593.03		41,442.43
Wisconsin	15,000.00	15,000.00	20,000.00	249,637.45			59,657.96
Wyoming	15,000.00	15,000.00	20,000.00	54,454.15	15,659.04		9,488.06
Total	720,000.00	720,000.00	960,000.00	6,526,818.02	663,834.29	590,034.17	1,470,550.11

[1] Not including balances from Federal funds.
[2] Supported by direct appropriations to the United States Department of Agriculture.

equipment, experiment stations, 1926

Miscellaneous	Total revenue	Additions to equipment						
		Buildings	Library	Apparatus	Farm implements	Livestock	Miscellaneous	Total
$10,000.00	$116,741.80	$3,691.03	$958.82	$1,537.50	$4,368.08	$238.50	$1,992.62	$12,786.55
76,240.00	76,240.00							
	156,166.11	1,200.00	250.00	2,992.40	2,586.75		5,000.00	12,029.15
	122,355.76	2,000.00	670.23	7,311.60	8,102.85	2,491.47	779.68	21,355.83
20,426.96	681,636.36	38,114.10	5,475.16	3,942.41	7,545.98	3,540.77	3,901.90	62,520.32
	218,939.71	15,775.00	972.00	3,656.00	3,391.00	8,722.00	2,455.00	34,971.00
10,500.02	222,354.50	9,000.00	1,000.00	4,550.00	1,000.00		1,200.00	16,750.00
19,033.31	79,934.44	445.54	2,737.79	335.47	408.27		3,135.80	7,062.87
	89,579.63	2,976.52	693.10	2,611.43	1,355.85	646.90	523.99	8,807.79
	340,454.30	70,152.59	5,432.65	14,172.20	1,079.23	378.42	1,120.00	92,335.09
	67,164.90		588.63	1,342.64	3,028.70	477.66	560.01	5,997.64
24,707.50	24,707.50							
54,940.00	54,940.00							
	100,933.07	3,000.00	100.00	301.00	300.00	6,000.00	500.00	10,201.00
	505,223.50	74,948.87	2,500.00				31,498.75	108,947.62
54,871.03	660,880.35	60,838.31	598.29	4,705.61	8,365.42	10,950.52	3,990.34	89,448.49
	360,093.38			3,155.26		2,063.50		5,218.76
	239,462.65	15,174.16	96.88	1,196.22	12,424.37	13,036.03	1,848.54	43,776.20
	348,976.01	3,931.21	1,203.94	1,104.40	615.19	1,182.45	512.65	8,549.84
14,120.52	152,187.63	8,702.87	203.97	873.17	7,533.64	2,553.00	2,123.29	21,989.94
995.40	118,662.32	5,352.51	872.59	1,804.97	2,918.20	525.00		11,473.27
16,338.20	164,094.76	3,339.35	838.75	1,375.30	3,081.45	2,384.35	2,109.85	13,129.05
2.20	239,727.58	1,487.19	553.84	2,103.15	2,297.87	475.00	1,208.06	8,125.11
946.74	374,999.42	27,808.86	1,465.06	4,174.77	9,202.30	5,087.60	848.27	48,586.86
2,249.97	456,526.46		2,027.13	5,640.19	4,698.53	3,720.96	20,133.06	36,219.87
	183,444.81	5,295.00	28.97	86.60	807.70	1,131.50	2,189.66	9,539.43
	185,280.08	5,609.34	259.37	2,359.41	1,853.58	6,937.21		17,018.91
1,069.80	180,215.93	1,323.28	291.25	1,408.10	4,251.00	1,489.00		8,762.63
	228,432.28	18,500.00	407.77	7,069.21	2,545.96	12,869.21		41,392.15
	57,988.54	1,947.82	108.50	832.48	1,419.02	2,500.00	118.50	6,926.32
18,876.71	79,017.31		528.29	1,124.05		200.00	374.40	2,226.74
132.53	205,732.10		1,910.36	8,928.97	4,504.98	2,465.45	1,819.19	19,628.95
	50,000.00							
	87,791.72	235.32	52.08	612.98	1,879.17	1,310.87	8,543.54	12,633.96
3.50	309,566.99	6,760.00	2,258.16	9,093.76	9,756.87			27,868.79
	314,254.23	1,905.35	1,619.97	3,284.22	3,908.02	99.15	5,444.42	16,261.13
385.58	130,207.20	3,471.00	300.07	2,512.55	2,340.01	3,686.00		12,309.63
11,025.00	453,625.27	1,000.00	441.77	1,987.48	5,317.16	9,444.29		18,190.70
4,024.72	942,037.44	128,014.96	370.31	3,138.99	18,987.18	10,638.38	2,169.51	163,319.33
	99,074.53	80,000.00	1,592.98	1,352.81	3,762.58	1,946.65		88,655.02
13,399.85	263,310.96	3,348.59	32.13	1,285.38	3,606.97	8,429.95	2,536.47	19,239.49
13,095.43	140,167.29	272.20	168.23	1,643.99	688.28	184.10	878.79	3,835.59
56,460.00	56,460.00							
	56,568.22		395.70	269.44	156.51	115.00	1,405.35	2,342.00
	166,423.49	1,240.00	9,646.01	4,491.82	1,698.76	1,864.00	5,875.82	24,816.41
	136,798.16			1,267.50	94.95			1,362.45
	105,548.76	870.69	1,551.92	1,217.96	3,594.56	1,164.86	2,041.89	10,441.88
66,907.24	504,064.00	36,642.35	413.31	10,501.23	12,982.10	5,456.16	3,825.67	69,820.82
	132,542.86	1,000.00	200.00	2,000.00	2,000.00	2,000.00	1,000.00	8,200.00
	67,280.82	2,735.78	355.64	484.87	152.25	482.30		4,210.84
1,961.51	144,090.25	3,803.66	640.00	905.00	900.00		1,460.00	7,708.66
22,180.00	22,180.00							
	210,612.81	2,226.33	757.79	364.90	1,891.64	478.00	1,462.78	7,181.44
	191,535.46	4,792.92	94.56	1,930.86	2,366.87	5,696.28	1,126.77	16,008.26
25,157.62	384,453.03	14,341.73	1,767.37	4,595.29	4,133.90	2,340.47	3,366.39	30,545.15
	129,601.25	16,794.80	900.00	8,238.92	3,230.96	3,828.50		32,993.18
540,051.34	12,191,287.93	690,069.23	56,331.34	151,874.46	183,134.66	151,231.46	131,080.96	1,363,722.11

TABLE 6.—*Expenditures of experiment stations from United States appropria*
June

Station	Amount of appropriation	Classified expenditures						
		Salaries	Labor	Publications	Postage and stationery	Freight and express	Heat, light, and water	Chemical supplies
Alabama	$15,000.00	$9,892.85	$1,808.87	$342.70	$509.43	$84.93	----------	$150.14
Arizona	15,000.00	14,998.46	----------	----------	----------	1.54	----------	----------
Arkansas	15,000.00	6,493.33	2,493.24	2,388.64	31.82	326.98	$62.46	322.27
California	15,000.00	15,000.00	----------	----------	----------	----------	----------	----------
Colorado	15,000.00	14,870.80	----------	----------	8.35	----------	----------	47.85
Connecticut (State)	7,500.00	7,500.00	----------	----------	----------	----------	----------	----------
Connecticut (Storrs)	7,500.00	7,500.00	----------	----------	----------	----------	----------	----------
Delaware	15,000.00	10,230.15	943.69	1,521.26	537.98	38.32	84.20	179.82
Florida	15,000.00	15,000.00	----------	----------	----------	----------	----------	----------
Georgia	15,000.00	8,919.04	3,027.20	----------	396.52	185.65	495.83	30.04
Idaho	15,000.00	12,026.28	1,356.49	200.41	----------	18.14	37.30	460.63
Illinois	15,000.00	14,834.60	165.40	----------	----------	----------	----------	----------
Indiana	15,000.00	14,860.00	----------	----------	----------	----------	----------	----------
Iowa	15,000.00	8,415.00	650.54	998.91	514.37	----------	49.58	124.18
Kansas	15,000.00	9,633.31	4,415.71	23.81	30.42	70.17	----------	104.77
Kentucky	15,000.00	15,000.00	----------	----------	----------	----------	----------	----------
Louisiana	15,000.00	7,529.19	4,195.86	----------	226.95	53.24	19.90	387.12
Maine	15,000.00	7,985.45	2,974.23	250.02	378.64	47.67	661.68	166.82
Maryland	15,000.00	14,355.24	610.69	----------	----------	----------	----------	8.75
Massachusetts	15,000.00	15,000.00	----------	----------	----------	----------	----------	----------
Michigan	15,000.00	15,000.00	----------	----------	----------	----------	----------	----------
Minnesota	15,000.00	15,000.00	----------	----------	----------	----------	----------	----------
Mississippi	15,000.00	9,634.50	2,498.29	----------	85.97	75.74	134.09	----------
Missouri	15,000.00	8,840.14	2,291.62	----------	213.11	36.22	67.44	131.36
Montana	15,000.00	14,986.86	----------	----------	----------	----------	----------	----------
Nebraska	15,000.00	15,000.00	----------	----------	----------	----------	----------	----------
Nevada	15,000.00	9,273.33	2,415.86	369.57	349.53	18.47	35.43	22.20
New Hampshire	15,000.00	10,241.83	523.04	1,322.81	713.72	315.77	700.00	25.28
New Jersey	15,000.00	10,716.01	829.00	----------	317.44	26.36	70.75	626.34
New Mexico	15,000.00	7,666.29	3,058.51	2,067.61	106.19	86.22	339.38	175.72
New York (State)	1,500.00	1,250.00	250.00	----------	----------	----------	----------	----------
New York (Cornell)	13,500.00	5,509.45	4,573.25	6.80	209.60	94.02	.68	27.35
North Carolina	15,000.00	13,183.38	249.82	----------	429.08	24.51	----------	264.65
North Dakota	15,000.00	15,000.00	----------	----------	----------	----------	----------	----------
Ohio	15,000.00	7,260.00	982.43	516.70	435.01	252.90	2,144.48	163.76
Oklahoma	15,000.00	5,590.00	2,487.04	763.90	130.94	283.40	59.00	1,088.17
Oregon	15,000.00	9,558.00	2,824.98	994.98	54.59	1.26	----------	85.24
Pennsylvania	15,000.00	12,000.00	798.79	1,760.34	2.47	51.91	12.82	----------
Rhode Island	15,000.00	7,250.41	3,203.47	1,260.43	133.64	193.11	120.89	1.50
South Carolina	15,000.00	8,378.32	1,121.20	518.68	544.67	50.45	232.30	94.15
South Dakota	15,000.00	8,228.25	3,020.25	1,863.81	36.44	24.30	----------	430.21
Tennessee	15,000.00	9,280.00	2,500.49	360.43	412.62	38.96	1,053.07	57.85
Texas	15,000.00	14,071.58	262.10	----------	352.09	1.01	----------	----------
Utah	15,000.00	8,925.46	2,278.34	----------	18.50	15.65	80.80	118.55
Vermont	15,000.00	8,060.15	2,416.25	1,347.22	413.27	44.42	947.87	398.01
Virginia	15,000.00	8,830.01	2,796.25	128.61	260.97	217.76	106.97	370.21
Washington	15,000.00	10,174.02	1,133.28	2,747.60	23.35	5.31	----------	17.55
West Virginia	15,000.00	8,857.50	2,738.56	565.00	7.92	----------	25.25	255.86
Wisconsin	15,000.00	8,350.00	2,388.22	667.24	336.90	5.28	----------	780.02
Wyoming	15,000.00	9,777.30	5,222.70	----------	----------	----------	----------	----------
Total	720,000.00	525,936.49	75,505.66	22,987.48	8,222.50	2,689.67	7,542.17	7,116.37

tions received under the act of March 2, 1887 (Hatch Act), for the year ended 30, 1926

Classified expenditures										
Seeds, plants, and sundry supplies	Fertilizers	Feeding stuffs	Library	Tools, implements, and machinery	Furniture and fixtures	Scientific apparatus	Livestock	Traveling expenses	Contingent expenses	Buildings and land
$230.03	$344.20	$457.82	$409.85	$341.86	$32.10	$198.00		$125.22		$72.00
1,304.23	3.00	702.25		27.05	345.00	87.52	$138.40	273.81		
18.00			10.00		45.00					
344.95	139.28		215.49	222.95	198.23	41.45		293.98	$8.25	
275.11	841.42	63.00	78.15	396.53	103.80	1.70		169.62		16.39
211.63		61.68		175.17		87.26	75.00	290.01		
							140.00			
519.72		3,668.12		26.50	12.63	6.71		13.74		
161.58			8.43	233.15		32.33		286.32		
424.58	58.17	35.50	5.11	908.19	306.98	40.85	120.00	452.76		235.60
109.89		797.90	389.79	15.11	229.72	252.67		270.54		469.87
						25.32				
533.72	478.54	1,069.20	14.40	75.83	1.50			328.22		70.00
719.27		1,795.60		127.57	255.76		493.00	3.00		25.91
								13.14		
296.72		401.82	107.50	261.00	130.85		391.70	436.77		489.25
88.07	245.92		397.00	14.90	69.20			323.76		18.70
274.87	15.39	360.00	9.60	121.54	32.70	81.40		1,453.49	6.89	58.22
258.25	370.03	94.45	2.30	463.78	78.50			175.93		56.84
811.41	428.01	.33	8.78	615.85	547.07	323.46		190.20	1.24	152.50
57.41						121.97		669.18		
1,339.95	578.09	150.00		129.46	416.66	630.56				
628.55	96.04	945.30	28.27	1,145.98	29.00	529.50		1,092.31		102.60
224.66	5.65	177.00		40.66	120.25	124.48		788.25		
255.32	80.06	9.00		29.29						
419.05	1,162.64	387.73	72.17	415.85	28.80			197.31	18.55	134.45
508.31	374.21		1,191.09	1,068.04	383.77	4.61	350.00	154.57		25.63
140.31		191.30		137.30	53.27	649.01		225.55		
119.34	58.65		242.73	65.16	202.78	2.00		384.43	3.71	217.78
11.05					120.37					181.80
240.23		2,129.22	12.70	102.63	6.75	6.85		855.45	15.00	193.87
196.04	56.66	6.60	125.96	187.29	190.10		15.00	451.25	67.73	76.18
484.05	84.00	1.35	204.85	139.80	45.06	291.55		266.34	23.15	749.07
73.28	146.51			30.60	20.50	61.65		566.35		
1,045.60	71.07	15.00	23.45	95.28		302.18		997.33		
58.84				61.55	661.42	1,654.46		36.07		
12,384.02	5,637.54	13,520.17	3,557.62	7,675.87	4,667.77	5,557.49	1,723.10	11,784.90	144.52	3,346.66

TABLE 7.—*Expenditures of experiment stations from United States appropria*
June

Station	Amount of appropriation	Classified expenditures					
		Salaries	Labor	Postage and stationery	Freight and express	Heat, light, and water	Chemical supplies
Alabama	$15,000.00	$11,250.00	$699.73	$42.38	$256.60	$214.73	$759.42
Arizona	15,000.00	12,906.86	593.45	6.15	24.83	----------	94.87
Arkansas	15,000.00	8,716.67	2,127.93	4.25	86.80	196.40	1,417.37
California	15,000.00	15,000.00	----------	----------	----------	----------	----------
Colorado	15,000.00	15,000.00	----------	----------	----------	----------	----------
Connecticut (State)	7,500.00	7,500.00	----------	----------	----------	----------	----------
Connecticut (Storrs)	7,500.00	7,500.00	----------	----------	----------	----------	----------
Delaware	15,000.00	11,156.63	511.76	6.35	47.49	----------	1,446.11
Florida	15,000.00	15,000.00	----------	----------	----------	----------	----------
Georgia	15,000.00	9,536.11	1,890.31	28.91	421.64	612.12	438.60
Idaho	15,000.00	11,193.34	1,181.97	----------	13.12	2.70	298.01
Illinois	15,000.00	11,814.86	3,185.14	----------	----------	----------	----------
Indiana	15,000.00	12,560.00	208.40	31.42	31.39	----------	489.82
Iowa	15,000.00	9,095.00	2,628.04	151.04	----------	115.90	895.90
Kansas	15,000.00	10,300.00	3,423.39	29.69	----------	----------	417.92
Kentucky	15,000.00	15,000.00	----------	----------	----------	----------	----------
Louisiana	15,000.00	11,896.90	780.00	107.20	16.68	5.87	83.12
Maine	15,000.00	15,000.00	----------	----------	----------	----------	----------
Maryland	15,000.00	13,905.01	----------	6.84	----------	----------	121.16
Massachusetts	15,000.00	15,000.00	----------	----------	----------	----------	----------
Michigan	15,000.00	15,000.00	----------	----------	----------	----------	----------
Minnesota	15,000.00	15,000.00	----------	----------	----------	----------	----------
Mississippi	15,000.00	11,049.83	2,188.90	----------	47.03	69.06	491.22
Missouri	15,000.00	4,074.31	3,341.76	117.51	291.73	153.85	1,797.04
Montana	15,000.00	11,624.84	1,961.64	35.20	17.10	----------	195.29
Nebraska	15,000.00	15,000.00	----------	----------	----------	----------	----------
Nevada	15,000.00	9,063.97	2,903.00	----------	10.08	70.28	368.07
New Hampshire	15,000.00	11,614.19	1,687.37	59.38	19.55	----------	380.35
New Jersey	15,000.00	12,457.50	332.16	33.57	3.28	736.76	959.30
New Mexico	15,000.00	9,142.82	2,731.51	95.94	226.97	420.99	772.88
New York (State)	1,500.00	1,500.00	----------	----------	----------	----------	----------
New York (Cornell)	13,500.00	9,366.02	1,289.87	290.55	21.33	----------	845.69
North Carolina	15,000.00	12,666.66	73.30	3.93	39.90	8.96	387.42
North Dakota	15,000.00	15,000.00	----------	----------	----------	----------	----------
Ohio	15,000.00	8,525.00	3,905.94	21.12	----------	----------	525.16
Oklahoma	15,000.00	10,780.00	1,384.02	----------	----------	----------	685.69
Oregon	15,000.00	13,709.99	582.82	11.61	26.96	27.95	386.63
Pennsylvania	15,000.00	13,012.10	1,393.84	----------	4.71	----------	204.50
Rhode Island	15,000.00	8,000.07	5,212.19	3.20	11.34	308.04	206.96
South Carolina	15,000.00	10,278.32	2,482.71	151.50	13.87	----------	333.25
South Dakota	15,000.00	8,378.22	3,031.63	2.08	207.60	9.50	592.47
Tennessee	15,000.00	13,520.00	330.50	5.95	73.30	83.00	269.69
Texas	15,000.00	13,276.54	546.13	50.22	82.35	38.34	419.34
Utah	15,000.00	9,712.44	2,715.16	31.16	85.31	----------	948.84
Vermont	15,000.00	11,800.84	2,094.53	40.35	6.16	192.03	272.61
Virginia	15,000.00	14,805.00	143.38	.50	----------	----------	29.97
Washington	15,000.00	12,710.26	1,323.54	22.94	----------	----------	159.78
West Virginia	15,000.00	12,371.71	638.59	3.64	.30	----------	564.74
Wisconsin	15,000.00	10,160.00	3,489.85	----------	----------	----------	441.57
Wyoming	15,000.00	14,580.00	420.00	----------	----------	----------	----------
Total	720,000.00	577,512.01	63,434.46	1,376.58	2,087.42	3,266.48	18,700.76

tions received under the act of March 16, 1906 (Adams Act), for the year ended 30, 1926

Classified expenditures										
Seeds, plants, and sundry supplies	Fertilizers	Feeding stuffs	Library	Tools, implements, and machinery	Furniture and fixtures	Scientific apparatus	Livestock	Traveling expenses	Contingent expenses	Buildings and land
$302.37	$7.00	$503.56	$1.53	$561.13	$12.16	$349.14	$1.50	$50.74		$6.01
128.86	38.55		13.25	115.55	88.25	262.55		474.59	$230.05	22.19
603.32	142.70	507.99	32.67	196.31	20.00	657.60	117.10	157.06		15.83
253.39	70.66		50.06	35.28		1,161.77		260.50		
196.52	9.50	1,205.87	97.97	12.14	4.55	248.18	144.00	37.25		116.
89.01				215.45		940.28		1,066.12		
279.32				46.65	7.50	555.53	710.75	75.72	3.50	
634.21	31.00	536.42		1.25	173.50	730.96		6.78		
75.20	1.55	497.81		70.15	40.00	31.61	18.92			93.76
98.04		43.70	70.81	666.73	128.65			403.76		698.54
96.63				7.92	58.13	765.37		38.94		
170.26		428.73	84.47	72.10		297.40		74.60		26.40
520.77	25.75	3,224.51	34.50	297.49	171.88	521.88	138.50	41.63		246.89
101.19		44.00	5.50	51.73	68.50	166.57	139.60	586.84	2.00	
65.69		915.92			29.71	95.00	1,116.18	362.10		
91.82		455.18		63.03	21.70	181.88		43.62		381.93
120.32				7.58	66.60	163.75			38.16	81.02
197.92	145.55	104.45	18.47	491.57	184.05	243.53		44.88		178.47
621.07	3.00		12.05	188.50	216.17	642.45		3.30		
						1,749.08		70.75		
136.37		105.13		18.52	16.35	1,329.66	416.75			
314.14	12.60	876.21	22.79	142.71		580.00	75.00	69.14		57.70
52.63	35.21	28.00	5.00	5.55	9.50	110.80		7.35		
51.56	47.50		168.23	14.86		63.31		39.39		
92.22	18.00	652.39	103.21	49.88	.70	85.65	115.00	50.67		90.48
189.98	300.00		6.80	134.47	30.00	652.13		426.97		
1,119.64	52.39	240.22		80.72	60.00	250.37	255.00	720.16		
1.63			30.62	52.42	49.05	208.19		69.18		306.47
108.14		355.47		2.30		121.17				
248.56			22.32	82.65		491.62		513.66		148.28
156.25	11.55	.32	22.49	16.42	52.90	219.74		15.96	1.72	96.13
1.56					1.50	.59				17.50
103.65			7.00	27.50		14.50		630.83		
197.65		379.52		57.72	3.12	475.61		307.40		
37.20		377.98		126.01		341.74	25.65			
7,457.09	952.51	11,483.38	809.74	3,912.29	1,514.47	14,709.61	3,273.95	6,649.89	275.43	2,583.93

TABLE 8.—*Expenditures of experiment stations from United States appropria ended June*

Station	Amount of appropriation	Classified expenditures							
		Salaries	Labor	Publications	Postage and stationery	Freight and express	Heat, light, and water	Chemical supplies	Seeds, plants, and sundry supplies
Alabama	$20,000	$11,155.84	$1,924.64		$99.15	$428.16	$184.95	$1,354.51	$543.70
Arizona	20,000	12,569.68	683.54		33.80	184.54	9.25	510.68	81.66
Arkansas	20,000	10,365.32	2,533.05	$1,099.98	598.46	43.54		250.82	24.20
California	20,000	16,991.67	2,964.55						
Colorado	20,000	16,382.05	604.00		222.56	7.32	6.35	131.96	47.66
Connecticut (State)	10,000	7,253.68	1,077.08		63.74			170.13	23.19
Connecticut (Storrs)	10,000	4,788.70	3,111.04						
Delaware	20,000	12,964.13	505.09	327.75	52.13	38.42		874.02	298.84
Florida	20,000	7,027.81	94.95		405.19			370.99	102.56
Georgia	20,000	8,319.78	1,680.54		169.38	661.70	423.69	291.58	392.12
Idaho	20,000	9,006.90	461.35	288.33	74.32	100.87		117.62	343.15
Illinois	20,000	12,803.37	934.49	137.42	374.91	105.24		92.39	56.74
Indiana	20,000	11,296.67	4,335.16		168.87			28.98	4.20
Iowa	20,000	5,427.30	3,403.61	44.55	153.63	25.73	18.01	519.79	2,098.49
Kansas	20,000	10,000.00	8,022.99	17.50	17.50	9.60		295.46	84.46
Kentucky	20,000	17,170.29	651.50		5.06	6.73		507.44	87.90
Louisiana	20,000	13,402.96	429.74		92.49	403.97	82.30	670.84	58.25
Maine	20,000	14,911.41		2.25	88.88			30.88	6.36
Maryland	20,000	12,553.39	1,380.00	11.20	264.43	2.95		345.70	
Massachusetts	20,000	12,290.00	1,435.86	484.00	258.76	6.95		164.89	6.80
Michigan	20,000	13,315.27	2,034.69	91.84	317.92	13.88		112.73	1,009.89
Minnesota	20,000	15,916.64	589.52	84.02	92.63	3.17		498.31	
Mississippi	20,000	11,999.88	2,909.03	59.40	113.89	178.02	34.45	22.51	249.17
Missouri	20,000	11,225.47	3,263.86	44.98	400.62	193.98		304.91	623.59
Montana	20,000	11,643.15	2,954.99	5.75	194.15	22.84		219.73	266.62
Nebraska	20,000	14,329.01	870.95	445.66	26.07	56.00		532.88	
Nevada	20,000	8,825.00	2,066.88	5.81	72.38	40.17	47.39	53.67	559.40
New Hampshire	20,000	11,187.25	2,103.11	727.50	51.77	36.17	13.27	199.87	129.39
New Jersey	20,000	12,887.50	655.50		111.18	27.96	92.16	653.24	200.72
New Mexico	20,000	8,686.64	1,974.18	9.07	314.92	93.23	70.38		245.82
New York (State)	2,000	1,800.00	133.43						
New York (Cornell)	18,000	13,118.82	246.03	22.50	261.40	2.67		198.35	85.59
North Carolina	20,000	9,764.95	3,978.58		253.98	27.95		38.20	63.55
North Dakota	20,000	16,796.55	157.50		76.28				99.08
Ohio	20,000	16,490.01	1,355.74		2.87			30.52	219.48
Oklahoma	20,000	11,370.75	1,996.56		83.53		18.00	675.15	359.75
Oregon	20,000	12,150.00	1,389.53	398.35	168.71	70.00	5.77	370.41	424.00
Pennsylvania	20,000	13,281.19	597.94		260.45	265.68	17.40	480.41	76.10
Rhode Island	20,000	12,750.10	2,016.67		287.56	49.89	387.08	162.45	107.52
South Carolina	20,000	7,000.00	6,523.46	1,215.62	345.38	20.46	1.34	18.53	172.12
South Dakota	20,000	12,925.26	2,884.18		70.39	73.66		630.04	9.15
Tennessee	20,000	12,846.05	1,024.40		31.00	239.37	140.90	988.66	353.19
Texas	20,000	4,076.85	2,511.47		375.68	218.32		419.95	299.03
Utah	20,000	11,724.98	2,251.65		240.98	161.96		376.29	379.76
Vermont	20,000	8,966.02	3,338.93	534.83	277.62	21.09	159.71	590.99	55.68
Virginia	20,000	11,280.97	1,789.71	668.20	646.01	48.55			
Washington	20,000	12,868.28	2,220.58	1,560.10	171.72	2.33		3.43	736.66
West Virginia	20,000	11,281.88	3,091.13	158.15	19.25		123.68	611.79	325.86
Wisconsin	20,000	13,656.17	2,525.54		79.87	40.76	16.25	82.64	547.85
Wyoming	20,000	16,648.97	584.88	18.17	14.43			117.34	30.14
Total	960,000	577,494.56	96,273.80	8,462.93	8,505.90	3,933.83	1,852.33	15,121.68	11,889.39

tions received under the act of February 24, 1925 (Purnell Act), for the year 30, 1926

Classified expenditures										
Fertilizers	Feeding stuffs	Library	Tools, implements, and machinery	Furniture and fixtures	Scientific apparatus	Livestock	Traveling expenses	Contingent expenses	Buildings and land	Balances
$303.04	$367.88	$174.29	$1,000.09	$720.61	$786.16	$237.00	$106.44		$613.54	
566.56			281.41	351.20	1,603.08		1,897.13	$50.38	1,177.09	
	248.60	18.00	14.00	2,718.79	342.60		1,742.64			
							43.78			
	6.85	91.29	1.80	227.80	213.55		1,975.76	75.00	6.05	
			432.25	27.00	205.79		699.74	47.40		
				375.00			1,725.26			
4.61	323.38	138.70	101.44	686.76	1,408.21	97.80	1,065.65	4.00	404.17	$704.90
	6.85	120.38	171.95	2,505.37	2,103.98	35.42	2,681.13	1.42	895.74	3,476.26
11.00	2,928.18	23.80	2,318.72	17.25	967.16	326.36	615.06	16.88	836.80	
	18.19	46.61	916.43	150.30	420.85	5,167.00	2,888.08			
		6.34	523.73	1,151.30	1,884.97	20.00	1,909.10			
				450.15			3,711.97	4.00		
	2,041.14		117.28	214.62	431.31		1,469.71		2,000.00	2,034.83
	66.10		123.84	84.70	217.24	435.42	570.66		54.53	
	3.58	37.85	9.00	153.00	444.37		923.28			
	7.73	13.77	2,274.62	200.90	712.81	700.00	885.07		64.55	
	428.88		465.15		184.87		3,869.32	12.00		
	206.23	12.52	638.34	954.41	395.18	88.00	1,791.21		1,356.44	
		4.70	25.54	547.50	870.62		3,904.38			
	9.00	24.56	.75	960.52	328.80		1,773.91		6.24	
				628.28	838.33	28.00	1,136.62		184.48	
466.05			1,004.14	344.03	128.10	1,186.65	1,120.48		184.20	
	1,434.02	10.07	451.86	391.57	83.64		911.04	2.05	658.34	
	180.00	58.04	760.37	748.01	474.90	74.00	2,396.95	.50		
	1,111.36		47.28	556.60	581.39	185.00	1,231.50		26.30	
53.50	1,070.51	1.00	1,625.12	691.73		2,150.00	1,278.87		1,458.57	
395.85	120.66	6.39	158.56	89.93	188.34		3,484.21	20.00	1,087.73	
	30.47	8.50	1,212.90	617.76	1,537.85	112.00	1,324.40	33.97	493.89	
	1,098.62	18.00	1,342.48	678.70	369.45	265.00	3,044.71		1,788.80	
							66.57			
	440.86	8.50	91.24	1,814.97	177.61	36.00	1,484.66		10.80	
	3,652.54			416.50			1,803.75			
	1,059.60	10.85	97.72	244.45	272.35		1,043.45		142.17	
	1,150.00		195.80		257.54		298.04			
	1,635.60		1,417.41	456.40	204.51	1,234.25	1,143.59	4.50		
2.00			877.12	993.21	188.02		2,961.88	1.00		
			501.54	1,086.00	667.63		2,493.46		272.20	
44.00	2,112.94	217.29	566.21	261.29	193.69		412.01		431.30	
39.00	802.62	96.24	161.15	877.85	136.57		2,482.17		107.49	
	608.34	7.55	21.75	956.57	776.29		1,036.82			
		710.35	1,240.28	767.05	721.24		712.91	.21	224.39	
	252.06	107.00	196.95	2,460.01	6,874.42	109.31	611.57		1,487.38	
	365.85	48.53	880.53	140.50	310.95	788.00	2,251.75		78.27	
	537.47		658.88	1,772.27	260.23	467.30	1,186.91	16.28	1,155.79	
		5.00	449.25	1,811.81	325.00		2,962.35		13.15	
		12.73	60.10	553.90	21.32		1,721.40		67.45	
	1,379.95		163.25	490.84	866.84	96.28	1,302.72	75.00	13.38	
	126.70		655.82	149.33	243.11	79.00	1,136.44	.90	659.62	
	666.70			225.00	8.10	233.25	1,453.02			
1,885.61	25,899.46	2,038.85	24,254.05	32,721.74	30,228.97	14,151.04	80,743.53	365.49	17,960.85	6,215.99

TABLE 9.—*Disbursements from the United States Treasury to the States and Territories for agricultural experiment stations under the acts of Congress approved March 2, 1887, March 16, 1906, and February 24, 1925*

State or Territory	Hatch Act		Adams Act		Purnell Act
	1888–1925	1926	1906–1925	1926	1926
Alabama	$568,956.42	$15,000.00	$266,619.89	$15,000.00	$20,000.00
Arizona	534,803.10	15,000.00	269,955.61	15,000.00	20,000.00
Arkansas	568,139.12	15,000.00	269,900.00	15,000.00	20,000.00
California	570,000.00	15,000.00	269,926.84	15,000.00	20,000.00
Colorado	569,718.82	15,000.00	268,638.93	15,000.00	20,000.00
Connecticut	570,000.00	15,000.00	270,000.00	15,000.00	20,000.00
Dakota Territory	56,250.00				
Delaware	568,382.87	15,000.00	265,475.12	15,000.00	20,000.00
Florida	569,966.04	15,000.00	269,996.06	15,000.00	20,000.00
Georgia	565,593.43	15,000.00	257,092.87	15,000.00	20,000.00
Idaho	494,324.13	15,000.00	265,842.22	15,000.00	20,000.00
Illinois	569,564.95	15,000.00	269,851.62	15,000.00	20,000.00
Indiana	569,901.19	15,000.00	270,000.00	15,000.00	20,000.00
Iowa	570,000.00	15,000.00	270,000.00	15,000.00	20,000.00
Kansas	569,995.00	15,000.00	270,000.00	15,000.00	20,000.00
Kentucky	569,996.57	15,000.00	270,000.00	15,000.00	20,000.00
Louisiana	570,000.00	15,000.00	270,000.00	15,000.00	20,000.00
Maine	569,999.62	15,000.00	270,000.00	15,000.00	20,000.00
Maryland	569,967.40	15,000.00	269,236.48	15,000.00	20,000.00
Massachusetts	569,617.70	15,000.00	270,000.00	15,000.00	20,000.00
Michigan	569,676.10	15,000.00	266,341.20	15,000.00	20,000.00
Minnesota	569,917.78	15,000.00	269,345.00	15,000.00	20,000.00
Mississippi	570,000.00	15,000.00	270,000.00	15,000.00	20,000.00
Missouri	565,097.24	15,000.00	269,999.90	15,000.00	20,000.00
Montana	480,000.00	15,000.00	267,417.04	15,000.00	20,000.00
Nebraska	569,932.16	15,000.00	270,000.00	15,000.00	20,000.00
Nevada	569,214.32	15,000.00	268,180.28	15,000.00	20,000.00
New Hampshire	570,000.00	15,000.00	270,000.00	15,000.00	20,000.00
New Jersey	569,949.97	15,000.00	269,392.06	15,000.00	20,000.00
New Mexico	534,509.05	15,000.00	270,000.00	15,000.00	20,000.00
New York	569,757.18	15,000.00	269,463.01	15,000.00	20,000.00
North Carolina	570,000.00	15,000.00	255,000.00	15,000.00	20,000.00
North Dakota	511,502.26	15,000.00	269,638.85	15,000.00	20,000.00
Ohio	570,000.00	15,000.00	268,514.02	15,000.00	20,000.00
Oklahoma	494,002.16	15,000.00	249,535.19	15,000.00	20,000.00
Oregon	555,156.64	15,000.00	265,000.00	15,000.00	20,000.00
Pennsylvania	569,967.43	15,000.00	269,995.41	15,000.00	20,000.00
Rhode Island	570,000.00	15,000.00	267,464.20	15,000.00	20,000.00
South Carolina	569,542.15	15,000.00	268,460.12	15,000.00	20,000.00
South Dakota	513,250.00	15,000.00	265,000.00	15,000.00	20,000.00
Tennessee	570,000.00	15,000.00	270,000.00	15,000.00	20,000.00
Texas	570,000.00	15,000.00	267,592.26	15,000.00	20,000.00
Utah	435,000.00	15,000.00	269,821.94	15,000.00	20,000.00
Vermont	570,000.00	15,000.00	270,000.00	15,000.00	20,000.00
Virginia	567,824.12	15,000.00	269,949.01	15,000.00	20,000.00
Washington	507,102.65	15,000.00	266,080.11	15,000.00	20,000.00
West Virginia	569,968.71	15,000.00	267,859.12	15,000.00	20,000.00
Wisconsin	570,000.00	15,000.00	270,000.00	15,000.00	20,000.00
Wyoming	555,000.00	15,000.00	270,000.00	15,000.00	20,000.00
Total	26,741,546.28	720,000.00	12,862,584.36	720,000.00	960,000.00

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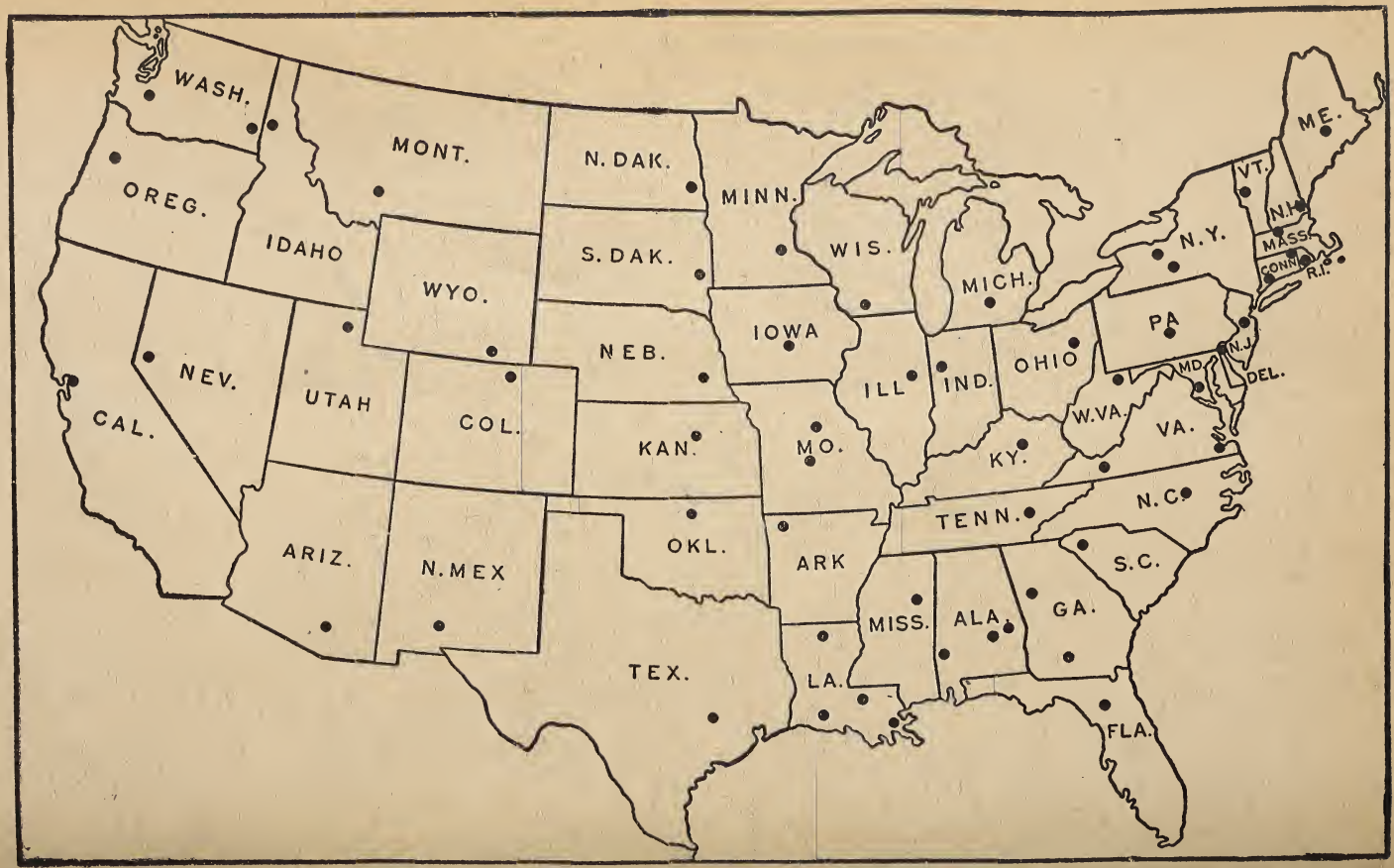

THE AGRICULTURAL EXPERIMENT STATIONS OF THE UNITED STATES